This magazine is published to promote sound thought upon and concerning industrial medicine and traumatic surgery. To that end it will contain articles, news items, reports, digests and other presentations, together with editors' comments. The editorial policy is to encourage frank discussion. On this basis contributions are invited.

Industrial Medicine

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Treatment of Syphilis

—*of the Central Nervous System*—

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IT HAS so often been said that the best way to cure a disease is to prevent it.* At a recent meeting in New York, Dr. John L. Rice, City Health Commissioner of New York, stated that there were 15,400 persons treated during 1934, in New York City, a gain of 50% over 1933, while in Great Britain the prevalence of syphilis had decreased 50% since 1920. In all of Norway, Sweden, and Denmark combined, which includes a population of 14,000,000, there were fewer than 1,600 cases reported in 1933. Moore and Merritt state that between the years 1912 and 1934 among 40,828 admissions of mental cases 28% were suffering from syphilis. Dr. Alfred Potter, director of Dermatology and Syphilology at Kings County Hospital, Brooklyn, put the number of syphilis cases in the United States at 10,000,000 with 400,000 new cases developing each year, with a mortality of 26,000. In those areas in the United States where syphilis is reportable since 1920, there have been reported 35,000 more cases of syphilis than of scarlet fever, 79,000 more cases than all forms of tuberculosis and 500,000 more cases than diphtheria. From those figures it seems that this country is rapidly becoming "syphilized".

In considering the treatment of neurosyphilis one must not lose sight of the fact that, after all, the burden must rest on the shoulders of the syphilographer, his neglect or persistence in carrying out the treatment early in its course.

This fact however, does not release the neurologist from his obligations, as the invasion of the nervous system occurs in 25% to 35% of all cases, and takes place comparatively early.

While the treatment of syphilis may seem a simple task, in viewing it on the surface, yet I do not know of a disease which requires more general knowledge of medicine, and the exercising of good judgment and the study of the individual case, than is required of the physician who treats the victim of this disease. General factors must be considered in dealing with the syphilitic from the therapeutic point of view. We must know the patient himself. We should understand his mental sensitiveness to the point that he sometimes regards himself as an outcast, his concern as to the possibility of its transmission to his wife and family; his innate feeling that his friends may recognize its presence simply by looking at him—in other words bringing to the forefront his emotions accompanied by his desires to consult his physician with greatest privacy.

It thus behooves the physician to impress upon the patient that he should look upon his illness as a disease common to many, and in this way direct his mind away from the idea that it is a sin, away from the moral point of view. Likewise when the patient becomes really despondent in having to undergo such a prolonged and consistent treatment through repeated injections he should receive the strictest attention possible from his physician and be encouraged in every way possible, because it is a long and trying experience, no doubt aggravating the mental state because of the feeling that he has a secret which he cannot divulge or discuss with his closest friends, so that he will not be classed as an "unwelcome guest." Such a man may develop an anxiety neurosis or become melancholy.

Thus the treatment of the patient from the psychological standpoint is very important. I remember as a medical student that my room-mate would listen to a lecture on tuberculosis and then would expectorate soot-mixed sputum and develop symptoms of tuberculosis. The following week he might develop imaginary syphilis, or typhoid fever, or the stiff neck of meningitis. Last week a father who thought he had had syphilis, on noticing that another child could not obtain the knee kick of his daughter, brought her in to have a careful examination for possible hereditary lues, cautioning secrecy as to why she was undergoing the examination. It was a guilty conscience on the part of the father, producing this fear for past indiscretions.

* Read before the Congress of Railway Surgeons, Chicago, September 20, 1937.

Patients frequently go to the library for information, as did this father, only to make themselves more miserable. The reading of textbooks by patients should be prohibited. When the physician encounters such mental reactions as fear and melancholia in a patient under treatment, he should give him a rest period between the series of treatments.

Another difficulty, and a common one, is in carrying out a properly arranged routine treatment of the patient who is engaged as a traveling salesman. To do justice to such patients the family physician or the specialist should refer him to some physicians residing in the different cities he visits and at the same time write complete instructions as to what drug should be given, the method of administration, the size of the dose and the date on which it should be given. The coming in contact with different physicians is not conducive to the welfare of the patient, as he becomes inquisitive in order to obtain the different opinions, and unless the different physicians understand the need for prolonged and regular treatment they may cause the patient to become careless or confused.

Then the spirochete itself must necessarily be considered. There may be a certain strain that tends to attack the central nervous system more frequently than do others, and likewise a lack of body or tissue resistance of certain individuals either through inborn tendencies or certain idiosyncrasies. Is the patient an alcoholic? Pregnancy in women requires careful attention in outlining treatment. The presence of infections must also be recognized.

In carrying out the medical treatment itself, the patient's hereditary tendencies to disease in general, his allergic reactions and instability, the age of the individual, sex and race, must be taken into consideration. It is common knowledge that the negro is especially prone to develop bone syphilis or cardiovascular syphilis, rather than the parenchymatous type. As we have said, the strains of the spirochete may tend to attack different tissues in different individuals. It is claimed by Reasoner that in some individuals who are blood relations, the organism may produce neurosyphilis, in others choreoretinitis. Others believe it depends more on the factors possessed by the patient rather than on the strain of the spirochete.

Routine lumbar puncture should be made early in the disease as it is the only means of early diagnosis of asymptomatic neurosyphilis, and thus serves as a means of reducing the number of cases of symptomatic neurosyphilis by employing intensive treatment early in the course of the disease. It has been said so often that it is almost an axiom that syphilis poorly treated early in its course, is more likely to invade the central nervous system than will syphilis that is left untreated. Too often does the average patient receive only a few treatments intravenously or perhaps a few intramuscular injections of bismuth or mercury in the hip or a short course of mercurial rubs and iodides—and the chancre heals. There is no pain to warn the patient of the danger of neglecting his treatment and he is lost sight of, only to return a year or two later with a syphilitic meningeal involvement, or perhaps he returns a few years later complaining of the lancinating pains of tabes.

In most instances the physician is to blame for not impressing upon the patient's mind the importance of early intensive treatment.

We must ever keep in mind the fact that a very few treatments may cause the blood to become Wassermann negative even though the meninges may be decidedly involved.

IT MIGHT be well to give at this point a classification of neurosyphilis.

The early type is the meningeal syphilis—asymptomatic and symptomatic. This type, as we have stated, occurs usually within the first two years following the primary infection. The treatment in this type should consist of alternating courses of bismuth, mercury and iodides, and if in a clinic well equipped for teatment, arsphenamin given weekly until eight to ten doses are given, as constituting one course. In private practice neoarsphenamin is more frequently employed. During the treatment, examination of the spinal fluid about once in three months, should be made. Unless definite clinical signs present themselves, rest periods of a few weeks will not prove harmful as long as one can feel assured that the clinical and laboratory findings are kept in check or rendered negative and kept so for two or more years.

The meningovascular syphilis includes gumma of the central nervous system—hemiplegias; the epilepsies—myelitis, etc. (the negro is especially prone to this type of syphilis). In the treatment of this class one must be more guarded in the employment of the arsenicals, such as the arsphenamines, especially if the aorta is diseased. I have known aneurisms to develop through the indiscriminate use of this class of drugs. Bismuth, mercury and iodides should be the preparations used, or otherwise the arsenicals in modified doses. Tryparsamid and fever therapy are not indicated, and may even prove a danger. As Moore says, a radical cure of the syphilitic is not the treatment to be used in vascular syphilis, as one can not replace dead tissue in the intima or media of the aortic wall, nor remake distorted valve leaflets. The chief aim is to heal the active inflammatory process. In the meningovascular syphilis, the consideration of the vascular side should rank first in observing care that no harm is done, even if good results have not been obtained. It is better to have a partial cure and a living patient, than an attempted cure with a doubtful outcome, and, as Ochsner once said, be willing to leave something to God.

It is with difficulty at times that the interstitial form of syphilis can be differentiated from the parenchymatous and besides cardiovascular symptoms are present 17 to 24% in tabetics and paretics. It is not within the scope of this paper to discuss those problems. Consequently we will pass on to the later forms of syphilis, namely the optic atrophies, tabes and general paresis, accompanied as

they are by visual disturbances, gastric symptoms, bladder disturbances, girdle pains, ataxia, abnormal reflexes, mental changes, etc., as well as the more or less characteristic reactions in the spinal fluid.

Personally I have not had any great experience in the treatment of primary optic atrophy. We know that subdural injection of arsphenamized serum has been used and by some considered the most satisfactory method of approach. It is taken for granted that the standard treatment has previously been employed. We have recently given such a patient fever therapy. There is but little hope if the vision is worse than 20/60.

In tabes, any treatment is discouraging. In early tabes, bismuth courses of three to five, mercury and iodides, and later neo-arsphenamin in moderate doses, and in repeated doses alternating with the above are indicated. The bladder must receive proper attention because of the retention so frequently present. For gastric crises Stokes recommends injections of epinephrin, $MgSO_4$ 5% to 20% solution injected intramuscularly, or, as some authors advise, 1 to 2 cc. of a 25% solution injected intraspinally. Large doses of chloral and bromides per rectum, resection of the posterior roots as first recommended by Foerster, or even chordotomy in stubborn cases might be considered. We have employed x-ray therapy with success in relieving the pains of herpes zoster and Hans Reese, of Madison, Wisconsin, states that he uses the same treatment in dealing with the lancinating pains of tabes.

If no improvement is shown after a series of such treatments, as reflected in the patient's clinical symptoms and the reactions in the spinal fluid, then tryparsamid and fever therapy are the agents of choice. These may be preceded by a standard course of treatment. Personally we are producing fever by the use of typhoid and paratyphoid vaccine in properly regulated doses, and we experience but little trouble in obtaining the degree of temperature desired, namely 104° to 105.5°.

Such reactions are obtained every second day until 10 to 12 treatments are given. Tryparsamid may be given intravenously in 3 gm. doses once a week during the fever therapy, or alternating with it. Other forms of fever therapy are highly recommended, preferably malarial treatments, diathermy, radio-thermy, sulphur injections, rat-bite fever, etc. I can but believe that the reactions of the body tissues and the ability to destroy the spirochete are more efficiently brought about by those agents which through chemical methods are produced in the tissues themselves by protein or malarial therapy, than through the application of external heat-producing agents. And again the mortality through protein therapy is nil. It is somewhat greater in malarial therapy, and still greater with diathermy.

I wish to go on record as being against raising the patient's temperature above 105.5° at any time.

Complications

THE complications include the following: Blood dyscrasias, probably due to action on the bone marrow.

Gumma of the larynx.

Aortitis with occlusion of the vessels.

Argyria.

Hemorrhagic encephalitis.

Convulsions.

Transverse myelitis.

Jaundice.

Optic atrophy aggravated by tryparsamid in 5% of the cases.

One must examine the acuity of vision and fields of vision form and color.

Bismuth was first used in 1921, and now is used more than mercury. It may be administered as follows:

Of bismuth salicylate (64% metal), 10% in oil, the dose is 0.2 gm. once a week. The injection is painful. Of bismuth potassium tartrate, 10 to 20% in almond oil, 0.2 gm. is the dose; of bismuth sodium tartrate, containing 73.8% bismuth, the dose is 0.3 gm. three times a week. The chief damage done by bismuth is to the kidney and liver only, and when the oil preparation is used mercury has a spirocheticidal effect in the test-tube, and is a good adjunct to arsenic in the treatment. It is chiefly eliminated by the kidney and intestines.

Preparations of mercury, protiodide, succinimide, 0.1 gm. daily. Injection of mercury, 25 to 50% strength, is perhaps the best method. There are preparations in oil to be given intramuscularly.

The iodides are indicated in bone syphilis, gummas, and generally assist other drugs to penetrate.

Summary:

THE principles of treatment of neurosyphilis as laid down by Moore are valuable:

1. Identify the type of neurosyphilis as accurately as possible by neurologic-psychiatric and serologic study.
2. Be familiar with the patient's general and physical status. Has he cardiovascular syphilis, or other complicating diseases?
3. Familiarize yourself with the various treatment methods, including tryparsamide, subdural and fever therapy.
4. Aim of treatment is first symptomatic relief; second clinical arest; third serologic normality.
5. Proceed by system of trial and error using least drastic methods first.
6. Gauge changes in treatment by clinical progress first, and next by serologic methods.
7. Give each method of treatment a trial of six months controlled by spinal fluid examination.
8. Treatment must be prolonged. The minimum is two to three years.
9. If spinal fluid changes prove refractory to treatment always advise fever therapy.
10. Rigid post-treatment observation with frequent physical and serologic re-examination.

Note: Unlike response to drug treatment, the value of fever therapy may not be noticed until one year or 18 months have elapsed.

Discussion:

DR. LEROY H. SLOAN, Chicago: Since the Illinois Central Hospital opened in Chicago a routine Wassermann has been run on every hospitalized patient. During the course of that time we have accumulated about 20,000 tests, and a short time ago Dr. Quin and I reported to the Society of Internal Medicine the results of those tests. I thought you, too, might be interested in them.

Among the 20,000 railroad employees, about 8 to 10% run positive Wassermanns or positive Kahns. In a general way about 10% of the railroad employees have syphilis and about 10% of the population have syphilis, so that syphilis itself is not any more common among the general run of employees of the railroad than it is in the general population, unless you begin to analyze groups of *laborers* and balance them against the general run of population in which case you will get a higher percentage among the laborers. Colored groups or Mexicans show a high percentage of syphilis, as a rule, but out of this whole group of 20,000 employees, of which there were many Mexicans, only two of these Mexicans showed any evidence of active progressive syphilis either in the cardiovascular system or any other place. It was a serological syphilis rather than active syphilis.

Another thing we learned was that the history is of no importance in railroad employees. If you ask the patient if he has ever had a chancre, 99 times out of 100 he will say no, but when you go back to that patient with a 2+ positive Kahn or Wassermann test and ask him, "when did you have a chancre," he will admit that about 15 or 20 years ago he did have a chancre. So with a positive Kahn or Wassermann test you can break down the patient's reserve and confirm the diagnosis many times.

We took these positive tests and went back over the histories to see if they checked with them, and we found that when we took into consideration such things as pupillary changes, ocular palsy, ptosis, aortitis, loss of knee jerks or Achilles jerks, the positive bloods checked up very closely in a high percentage of cases with the findings, but particularly we found that the positive Kahn tests were checking. From our studies we came to the conclusion that the Kahn test properly carried out is much more sensitive in the general run of railroad employees than is the Wassermann and that even the 2+ Kahn is of greater importance. When a 2+ Kahn is present it is up to us to prove that the patient does not have syphilis rather than that he does have syphilis.

We confirmed the findings that in the colored patients *cardiovascular syphilis* is most common. In the white patients central nervous system syphilis is more common.

The findings of importance in checking and confirming the diagnosis in these patients, are the pupils, history or presence of ocular palsy, third nerve involvement, aortitis, aortic regurgitation, loss of knee or Achilles jerks.

Dr. Hall has pointed out that in the treatment of syphilis of the central nervous system the psychology of the patient must be given due consideration; he must be individualized in treatment as in other things. There is no shotgun prescription for this condition. The attitude of the patient, the family and the neighbors toward syphilis has to be given some consideration. I do not believe that a positive Kahn or Wassermann of itself necessarily indicates treatment. The older the patient the more dormant his syphilis may be and the less probably we need to push treatment; it is in the younger type that we should give treatment. The time to treat is right after exposure. Nowadays it seems that syphilis is something to be proud of, and I think all syphilographers are agreed that the time to treat the patient is when the chancre is present and not afterwards. Give good treatment with arsenicals during the course of the chancre and three or four years afterwards and thus prevent neurosyphilis. Dr. Hall has pointed out how the use of typhoid is really a part of office procedure. We have given typhoid a good bit but have not used much malaria. We have discarded the use of hyperpyrexia. We had one fatality and since then we have discarded it. We have used the inductotherm method with a temperature of 104° for a period of about four hours, which makes a satisfactory method of producing fever. Whether it produces an effect on the reticulo-endothelial system has not been shown, and that is why typhoid is perhaps better.

In the management of the vascular type of lesion where there is hemiplegia or an ocular palsy or some ptosis that indicates the meninges are involved or that there has been a thrombosis, those patients are adequately treated by old-fashioned mercury rubs, iodides, bismuth, and after such a course of treatment by arsphenamin and fever therapy. It is the cardiovascular type of lesion we have to watch out for. The patient often has an aortitis and if we give that man a fair dose of arsphenamin we may cause an angina pectoris. This is due to irritation of the middle portion of the aorta by the drug, with the production of an acute mesaortitis.

In the aortic lesions push iodides and mercury and bismuth and later on *small* doses of arsphenamin.

Treatment of spinal cord syphilis is bad. Tabes is not very susceptible to treatment and we have to use everything we can think of to secure an adequate result.

The treatment of syphilis resolves itself into treatment of the exposure period and good stiff treatment of the chancre; in the paretics fever therapy adequate to control and along the lines Dr. Hall suggested; in the meningeal vascular type use the old-fashioned mercury rubs, iodides and then fever therapy carefully given; in the pure vascular syphilis of the aorta watch out for neoarsphenamin in the early course of the treatment and push other medication.

We have listened to a very interesting paper and one which is apropos of the current interest in syphilis and for which we thank Dr. Hall very much.

DR. GEORGE W. HALL, Chicago, (in closing): Of course, there were a great many things I did not have time to bring out. I remember when I was a young man here I read a paper before the Chicago Medical Society, reporting a collection of cases from the Cook County Hospital of mistaken diagnosis. I reported some seven cases at that time which had been operated upon six to seven times for supposed gall-stones, cholecystitis, appendicitis, ulcer of the stomach, etc.

All of these were mistaken diagnoses and in each of them the individual had gastric crisis. I concluded my paper at that time by making the statement that if the surgeons would take more time to test the pupils and knee jerks of the patients, the patient would not leave the hospital with so many abdominal scars stating "opened by mistake." It is a thing we must always consider when we note abdominal pain; we must always be sure that we have excluded syphilis. The danger of the physician in the smaller city is that he knows his patients too well. He has known "Mr. Jones" all his life, and has seen him every evening at the corner grocery store and never thought of syphilis as the cause of his complaints. Then Jones comes in with pain in the abdomen, is vomiting, and of course the doctor thinks of surgery and not often enough of syphilis.

There are patients, especially in my line of work, who have syphilophobia. I have a few cases in that class. In those we have never been able to detect syphilis in any form, either by the physical examination or through the laboratory. Yet those people come in from time to time fearing they have syphilis. It is perhaps a psychological equation on the part of a guilty conscience, and they go on for years, and it is very difficult to make them think or believe that they never had syphilis.

On the other hand, Dr. Sloan has brought out a very important point, especially among the railroad employees. Not long ago a patient came in to my office and I asked what his complaints were and he said: "Not a thing." He insisted that he felt fine, that he had no pain, that he had been working every day. I finally asked him if he had seen any other doctor and he said yes, a surgeon of the railroad. I asked him what the topic of conversation was and he said the surgeon was joking him about his race

horse; he said that the horse ran in the Derby at Louisville and won $50,000 and he asked for a telephone to advise his trainer to enter her in the race that day because he was sure she could win. That man had general paresis.

I had another case of an engineer, running a fast passenger train, who ran through a red light and stopped his train within four feet of a freight train, across his right of way. He jumped from his cab and bragged about the stop he made. He was sent in by the surgeon and it was found that he had general paresis.

We have to be careful. In early tabes these men are apt to fall off the tops of cars and the railroad is responsible. We see as many as four and five such cases each year.

Relative to the age of the patient in giving arsphenamin, it is said that a man is just as old as his arteries, so that we have to consider that part of the individual in the treatment. We have to be very careful not to give it in too large doses, particularly in those patients who have arteriosclerosis. If we have evidence of the presence of arteriosclerosis, I think we should employ the milder treatment. If we use arsphenamin it should be given in modified doses and the patient should be under constant care because we may do more harm than good in the treatment of those cases.

Skull Injuries

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THE DIAGNOSIS of skull injuries rather automatically indicates the type of treatment that should follow.* It is very seldom that there is a necessity for extreme haste in brain lesions following trauma, and careful decision of the severity, type and localization of the injury is much more important than speed in taking the patient to the operating room. A fracture of the skull does not necessarily mean an intra-cranial pressure, and conversely a failure to find a fracture does not mean that injury to the brain can be eliminated from consideration. We should seek to determine:

FIRST, if there is intra-cranial pressure and the cause of it;

SECOND, if the intra-cranial pressure is damaging to the brain and if it is progressing; and

THIRD, if there is shock present and whether it is due to a disturbance of the brain cells with a resultant edema, or whether it is due to a hemorrhage.

If a spicule of bone should penetrate the brain, it is obvious that it must be removed and adequate drainage allowed, but with this exception, I believe that time should be allowed for the determination and estimation of the condition.

Certain outstanding symptoms will lead in the direction of the diagnosis. Cerebrospinal fluid pressure which is normally between 9 and 11 mm. of mercury, may elevate rapidly to two or three times that amount. Where pressure has been raised, it is evident that it must not be allowed to remain in that condition. While the mercury manometer gives the best evidence of an increase in the pressure of the cerebrospinal fluid, a choked disc, and a slowing of the pulse indicate that the same condition is present. We may have an injury to the brain with a condition which would ordinarily cause an increased pressure, but in which there is a seepage of the cerebrospinal fluid through the cranial vault to the extent that there may be even a decrease in pressure.

When this occurs it is usually perfectly evident that the cerebrospinal fluid is extravasating through a fracture and scalp wound or through a fracture underneath the scalp, with a marked swelling underneath the scalp. The history, and the physical examination of the patient, and his reaction are all important in determining what is happening. A patient who has been injured, rises and goes about his work for a period of time and then suddenly goes into coma, which gives definite evidence of a ruptured blood vessel in the brain with a small extravasation of blood which eventually becomes large enough to do damage.

Verbrugghen states:[1] "The classical syndrome of extra-dural hemorrhage is characterized by violence to the head with unconsciousness followed by a return to consciousness for a few hours, with a subsequent return to unconsciousness. The diagnosis is established mainly by the lucid interval followed by the return to unconsciousness. Very little emphasis is placed on the absence of the lucid interval and the presence of hemiplegia."

In those very severe cases which have a marked destruction of the brain with loss of cerebrospinal fluid, it is of course inadvisable to do anything except treat them expectantly. It is only in patients who have a fair chance of recovery to which these remarks are applicable.

Hemorrhage in the vault may not be the only cause of the pressure. A severe contusion which develops edema of the brain will temporarily increase the pressure very markedly, often to as great an extent as a hematoma. The intravenous injection of 50 cc. of a 50% solution of glucose will reduce this edema in a remarkably short time. A meningeoma caused by this condition will reduce in size during the process of an operation with an application of this treatment.

Fracture of the para-nasal sinus, or the mastoid may cause pneumocephalus which may develop a marked intra-cranial pressure. We must not overlook other injuries to the body which will effect a reaction on the brain. It is important that all injuries be evaluated at the time of examination to determine whether or not they are the chief source of the trouble, or are aggravating the brain injury. On entry into the hospital we may find that shock has so far reduced the blood pressure as to cause a brain anemia with a resultant coma. When this happens the administration of fluids will usually improve the patient's general condition and bring him out of shock.

A long continuation of the stuperous condition does not necessarily mean that there is an increased intra-cranial pressure. When the patient is unconscious for days and the pressure does not rise, there is usually a brain stem lesion and the prognosis is not good. After a long continued stupor with a lucid interval and return to con-

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* Presented at the Fourteenth Annual Meeting of the Association of Surgeons of the New York Central System, Cleveland, Ohio, September 14, 1937.

1. In *Am. J. Surg.*

sciousness there is evidence of a progressive lesion. In this latter condition, however, we can expect an increase above normal of the pressure.

It must be carefully determined whether the patient has bleeding or not. Frequently the diagnosis is extremely difficult and all of the aids possessed should be used. An examination of the reflexes may help in the localization of the trouble. The presence of a fracture on one side of skull does not necessarily mean that the clot, if present, is underneath the fracture. It may be there or it may be in the base due to a torn middle meningeal artery. It may also be present on the opposite side of the skull in the unfractured area, due to the principle of contrecoup. While a slow pulse rate may indicate compression, a rapid pulse rate will indicate a tear of the brain substance without compression. Changes in the pupils may also be an aid to the localization of the injury.

After a diagnosis of hemorrhage into the brain or extradurally is made, no time should be lost in opening the skull, with the intention of saving brain damage.

Cerebral compression is much more easily dealt with than is cerebral laceration. Intradural hemorrhage in most cases is a prognostication of a hopeless condition.

A rise in temperature means little until the condition is far advanced and the general appearance is such as to leave no question as to the outcome. When death is about to ensue the heat regulating center may be so badly affected by pressure, edema, or direct injury that the temperature may rise to 106° or 107° just before the end. Small variations of temperature may be evident, however, with the general condition of the patient showing an improvement.

The rate and depth of the respiration are of secondary importance in the diagnosis. They indicate the general condition of the patient in contradistinction to the condition of the type of skull injury. When Cheyne-Stokes respirations appear, we have a clean-cut indication that death will follow.

A study of the statistics of Mock, Dandy, and others, made on large series of cases treated by various methods indicate that 70% of all cases of traumatic skulls will improve with complete rest in bed and general supportive treatment; that 20% are hopeless from the beginning and no amount of treatment or care will save them; and that 10% are operable with the expectancy of recovery if taken at the proper time and careful surgery is performed, and that the large proportion of this last 10% is of the extra-dural hemorrhage type.

There has been much discussion as to the value of the lumbar puncture. In a questionnaire sent out by Mock to surgeons throughout the world, he elicited the response that the majority of men favored early lumbar puncture with a moderate reduction in pressure, and repeated as the case indicated. The contra-indications are:

First: The patient is obviously losing cerebrospinal fluid through the base of the brain or through the sinuses.

Second: The psychic shock is too great with a resultant greater damage to the patient.

Third: Children, because of the inability to perform the procedure without anesthesia.

Fourth: Severe intra-cranial bleeding which may be increased by the reduction of pressure.

In certain conditions this procedure is of the greatest value. As a diagnostic measure it is frequently the best indicator that we have, and it may save the patient's life when the coma is long continued.

The administration of the 50% glucose solution may have the same advantageous results as the lumbar puncture by the elimination of the cerebral edema.

The administration of morphine should be avoided because of the depressant action of the drug on the cerebral centers. Chloral hydrate or bromides will give better results in extreme restlessness with much less danger.

If the patient survives the first 24 hours after the trauma, vigilance must be exercised to avoid pneumonia to which these cases are particularly susceptible. Warmth, occasional inhalations of oxygen, and elevation of the head of the bed are the best means to avert this tragedy. There may also be a disturbance of the carbohydrate metabolism which should be determined by a blood sugar determination, and if found present insulin is administered.

Hemiplegias and paraplegias can not be avoided, but every effort should be made to save what residual activity there is by stimulation and passive motion. This should be continued over a long period and eventually a surprising amount of activity can be developed in the paralyzed muscles.

Meningitis may develop, usually beginning to show at the end of 48 hours, the infection entering through a fracture at the base, through the fractured sinuses, possibly at times through the blood stream infecting a small blood clot, or directly through a large open wound. General treatment can be tried, but it is usually a hopeless fight from the beginning. In these patients who survive and leave the hospital a certain number will eventually be found to have definite sequelae. Epilepsy will develop in a small percentage. Late trephine has been done with very little success. The administration of barbiturates will control some cases, but in others no relief or partial relief can be found. Persistent vertigo may be present due to injury to the inner ear. Very little can be done for those sufferers except by medication and long intervals of rest.

Headache may commonly follow cranial injury and this may be associated with a lessening of the mental acumen. After an examination of a large series of these cases by means of pneumoventriculograms many evidently had distorted ventricles due to the formation of adhesions, or had developed adhesions that hindered the absorption of the cerebrospinal fluid. I have known this to occur after what appeared to be a very moderate concussion. If the pressure of the cerebrospinal fluid is taken, it will be found elevated and when reduced a relief from the headache will often ensue.

The procedure may of necessity be repeated at intervals which will lengthen between tapping until after an indefinite period the pressure remains fairly stable and the headaches improve, together with a return to a normal mental acuity. I have had patients decide from their symptoms when the tapping should be done. The usual custom is to reduce the pressure to one-half of what it is at each tapping.

A change from a normal placidity of demeanor to a marked irritability of temperament which is permanent is also not uncommon. This is a result of frontal lobe injury.

Conclusions:

FIRST: Careful examination of the patient should be made by all available means before treatment should be instituted.

SECOND: 70% of these cases can be cured by rest and supportive treatment; 20% will expire, and 10% should be operated upon.

THIRD: 50% glucose injections and lumbar punctures are of great value in reducing the cerebrospinal fluid pressure due to cerebral edema.

FOURTH: Epilepsy, vertigo, headaches with a lessening of the mental acuteness, irritability and paraplegias are common sequelae of cranial injuries.

Bibliography:

FRASER, SIR JOHN: Head Injuries in General Practice, *Brit. M. J.*, 3979:739 (April 10, 1937).

JACKSON, HARVEY: Head Injuries, *Practitioner*, 138:188 (February) 1937.

MOCK, HARRY E., MORROW, A. R. and SHANNON, CHARLES E.: Skull Fractures, *Internat. Surg. Dig.*, 17:323 (June) 1934.

COLEMAN, C. C.: The Management of Acute Head Injuries, *South. M. J.*, 30:196 (February) 1937.

DAVIS, LOYAL: The Treatment of Cranio-Cerebral Injuries, *J. Oklahoma State M. A.*, 27:354 (October) 1934.

DANDY, WALTER E.: Diagnosis and Treatment of Injuries of the Head, *J.A.M.A.*, 101:772 (September 2) 1933.

FLEMING, HOWARD: Treatment of Head Injuries, *Southwestern Med.*, 19:261 (August) 1935.

JEFFERSON, GEOFFREY: The Treatment of Acute Head Injuries, *Brit. M. J.*, 3800:807 (November 4) 1933.

SWIFT, GEORGE W.: Head Injuries, *Am. J. Surg.*, 26:152 (October) 1934.

WERDEN, DELBERT H.: Drainage of Cerebrospinal Fluid in the Treatment of Acute Head Injuries, *Arch. Surg.*, 34:424 (March) 1937.

EARLEY, DANIEL E.: Study of One Hundred Cases of Skull Fractures Followed From Five to Thirteen Years, *J.A.M.A.*, 104:2332 (June 29) 1935.

FAY, T.: The Treatment of Acute and Chronic Cases of Cerebral Trauma by Methods of Dehydration, *Ann. Surg.*, 101:76, 1935.

The Treatment of Burns

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THE TREATMENT of burns is a very old subject, probably dating back to the first case of sunburn or possibly to the time when man first discovered fire and burned his fingers.* Unfortunately from that time up to the past decade it is evident from a perusal of the surgical literature that there has been no unanimity of opinion as to what constitutes the ideal or even the best treatment for burns. The number and variety of the methods that have been advocated from time to time tend to substantiate this fact. Only last year Williams and Kuhn reported a series of 1,200 cases of industrial burns in which 47 different methods of treatment were used.

The importance of having a satisfactory treatment for burns is at once apparent when we recognize the high mortality and the prolonged and deforming morbidity that accompanies this group of injuries. In the treatment of burns, we have a complex situation in that several factors have to be controlled. The treatment must aim (1) to stop pain, (2) to prevent toxemia, (3) to insure asepsis, (4) to prevent the loss of tissue fluids, and (5) to prevent contractures and scar formation. As these are the factors that govern the mortality or morbidity, it is evident that the value of a given treatment must be judged by its power to control these factors. Naturally, most of the methods that have been used have had some success in controlling one or more of these points; the ideal treatment is the one that is able to control all of them.

The treatment of burned patients usually consists of systemic and local measures. Within recent years, as a result of our increasing knowledge of the biochemical and pathological changes which occur following a burn, a standardized systematic treatment has been generally accepted. The clinical picture is that of surgical shock which must be combated immediately. Pain which is an important factor must be controlled by a sufficient dose of morphine or codeine. The anhydremia and blood concentration due to the enormous loss of body fluid are corrected by giving water by mouth and administering saline, alkaline and glucose solutions intravenously. At least 1,000 cc. of fluid for every 25 lbs. of body weight is necessary. Because the blood is concentrated, blood transfusions are not indicated, but the use of blood plasma obtained by centrifuging citrated blood is of value as the plasma stays in the vessels longer than aqueous solutions. Exsanguination transfusions which have been suggested by some Canadian observers are, in my opinion, of no use and should *not* be used.

When we come to the local treatment of burns it is evident that there is a great divergence of opinion as to what line of therapy gives the best results. The various methods employed may be grouped in general as follows:

1. The biochemical treatment, using a 10% aqueous solution of sodium bicarbonate as a wet dressing. It can be obtained in every household and is sterile and cheap. However, the dressings are very bulky and uncomfortable and very painful when changed. In my opinion its only value today is that of a first aid home dressing.

2. The paraffine or mechanical splinting dressing. This was first introduced at the time of the World War by the French who advocated the use of a wax impregnated with volatile oils called "ambrine." This was later simplified by using molten paraffine which was sprayed on the wound and covered with layers of cotton and gauze. The

* Read before the American Association of Railway Surgeons, September 21, 1937, Chicago.

dressing splinted the wound, was non-irritating, and protected the raw area. However, it did not prevent infection or stop the loss of body fluids. As it had to be changed frequently, it was unpleasant for the patients, who objected to the pain of a hot wax spray.

3. The fixation methods. The principle on which this mode of treatment is based is that of healing a wound under a crust. For this purpose antiseptic drugs which have a desiccating and fixing action on the tissue cells are sprayed or painted over the burned area, or dressings continually moistened with these drugs, are applied. To hasten drying and crust formation evaporation is encouraged by open dressings. The drugs that have been used in this method of treatment are absolute alcohol, aluminum acetate, picric acid, and tannic acid.

Dressings kept continuously saturated with absolute alcohol give remarkably good results. However, because of rapid evaporation, this method requires a great amount of attention and if the area involved is large the expense is considerable. Nevertheless, as it produces a minimum of scar tissue, alcohol is valuable in treating burns of the face.

Aluminum acetate consists of a 2% alcoholic solution of aluminum acetate mixed with a 2% solution of methylene blue in a preparation of 10 parts of the aluminum solution to one part of the methylene blue solution. This aluminum acetate solution is sprayed on the wound, a light gauze dressing is applied and drying is encouraged. A 1% solution of picric acid in 5% of alcohol is used in the same manner as the aluminum solution. This method gives good results and has been very popular. Its disadvantages are the yellow stain that it imparts to the linen that comes in contact with the dressing and, more important, the poisoning that may occur from drug absorption.

While the fixation treatment was a step forward it did not arouse much attention until Davison in 1925 advocated the use of tannic acid solution. He recommended a 2.5% solution of tannic acid applied as a wet dressing over the burned area. In 18 to 24 hours the site of the burn became covered by a leather-like crust composed of a devitalized tissue and a tannate of albumin formed from the wound exudate.

Davison based his treatment on the theory that the toxin present in the red cells was due to the absorption of the products of protein autolysis at the site of the burn. In order to limit this absorption he produced a coagulum of the devitalized tissues only, by the application of tannic acid. The dry crust thus produced prevented the loss of tissue fluids which leads to a lowering of the sodium chloride of the blood. He obtained in that way a marked lessening of the toxemia.

In addition, the tannic acid applications produced a definite analgesia and did not affect the normal skin. In the burned area, islands of epidermis from hair follicles and skin glands are preserved. Sepsis is avoided by the dry coagulum which forms an unfavorable nidus for bacterial growth.

The tannic acid treatment was a marked advance in the treatment of burns, and in 1929, I published a paper describing the very favorable results I had obtained by using it, not as a wet dressing but employed as a spray in a 5% instead of a 2.5% solution as originally suggested by Davison.

In the last few years further improvements have been brought forth. Oldrich pointed out that the crust produced by the tannic acid was very stiff and tended to crack about the joints. More important, he indicated that infection was not sufficiently controlled and stated that the toxemia was mainly due to pyogenic organisms. He suggested the use of a 1% solution of gentian violet applied as a spray. This forms a flexible thin covering and has a definite antiseptic and germicidal action. Its disadvantages, however, are that it takes two or three days to form a crust during which time much valuable body fluid is lost. It is not effective against gram negative bacteria and is difficult to remove when necessary. In addition, it is very unpopular because it stains all the bed linen. Acting on the thought that a bactericidal agent is necessary Bettman in 1935 advised the use of tannic acid with silver nitrate. This combination produces a thin flexible crust almost immediately and is strongly germicidal.

In our clinic we have had very satisfactory results with this method of treatment. Our usual routine is as follows: As soon as the patient is admitted a generous dose of morphine or codeine sufficient to control the pain is administered. If the individual is in shock the various systemic measures such as external heat and intravenous solutions are employed, and the local condition is not treated until the shock is overcome. Then the patient is given a dose of avertin and taken to the operating room. The area about the wound is cleansed with neutral soap and water. Any grease is removed with benzene, foreign particles are extracted with sterile instruments and all blebs excised. The wound is then sprayed with a 5% solution of tannic acid in water and then a 10% solution of silver nitrate is applied on a cotton applicator. A thin flexible crust forms almost at once over the wound. No dressing is applied and the patient is placed in an electric cage on a sterile sheet.

The systemic treatment is continued but nothing more is done locally. After the first half hour the wound becomes painless and remains so. The dry crust completely seals the wound and is insensitive. The patient is kept under the tent and no further local applications are made. At the end of three or four days, all evidences of toxemia usually disappear. Locally, if the burn is superficial, the crust begins to loosen at the edge as epithelization goes on and the loosened portion can be cut away with a scissors. In the deeper burns the crust usually loosens in from two to three weeks leaving a clean granulating surface which can be prepared for skin grafting by wet dressings of saline or Dakin's solution. If evidences of sepsis arise at any time holes may be made in the crust for the application of Dakin's solution or the en-

tire crust may be removed by softening it with vaseline. It has been found, however, that if wet dressings of boric acid are used, a rapid toxemia arises that is frequently fatal.

I have altered the method of Davison in applying the tannic acid by omitting the use of gauze dressings. When the coagulum was produced under gauze, it was sometimes difficult to remove the dressing as the gauze tended to adhere to the wound in places. By using the spray no dressings are necessary.

The solution advised by Davison was a 2.5% strength, but he stated that a solution up to 5% could be used. I have found that a 5% solution produces a coagulum more rapidly and does not seem to affect the uninjured tissue. Also, for burns about the face Davison suggested the use of a 5% tannic acid ointment. I have tried this, but it did not seem to act as satisfactorily as the 5% solution applied as a very fine spray.

The treatment of burns has undergone modifications and I hope will continue to improve from year to year. I feel that our modification of Davison's method is a definite improvement. The gentian violet advocates showed the importance of a flexible crust formed from germicidal drugs. We feel that the tannic acid silver nitrate is the best local treatment up to the present date. Changes in the treatment of these serious injuries will undoubtedly be advanced as time goes on. Just this month* Branch, of Detroit, has suggested the use of gentian violet and silver nitrate. I have had no experience with this method and so I am unable to comment on it. I will say that in my opinion the fixation method as exemplified by tannic acid with the addition of a powerful antiseptic such as silver nitrate is fundamentally sound and is the best method available today. I believe that any improvements will be founded on similar principles.

My experience in the tannic acid treatment of burns dates back to 1927. In the 10 years since that time we have treated successively in the hospital 382 burns, with a mortality of 5.2%.

I feel that this method is a real advance in the treatment of burns, and that, more than any other method, it has reduced the mortality figure. By the prevention of infection scar formation is reduced to a minimum, and skin grafting can be done very early if epithelization does not occur spontaneously.

The practical absence of pain by the analgesia of the tannic acid and the complete freedom from dressings is a joy, not only to the patients but as well to the surgeon who has to look after them. In the rather frequent burns about the buttocks and genital region that are so difficult to dress and keep clean, the advantages of this method are very apparent. There are no large weeping wounds, as the dry coagulum prevents the loss of body fluids. In the same way toxemia is distinctly lessened by the coagulation of the devitalized tissue which prevents absorption of toxic products.

In conclusion, it would seem that by controlling all of the factors required in the treatment of burns, the tannic acid and silver nitrate treatment where applicable is ideal. In addition, the treatment is inexpensive, as both drugs are cheap. The tannic acid solution can be readily made by adding one-half a teaspoonful of the powder to an ounce of water. As the powder keeps readily it should be placed in all emergency outfits. For obvious reasons, this treatment should be of decided value to industrial surgeons. Whenever possible, the tannic acid solution should be employed at the first treatment, for we have found it is very difficult to secure a good coagulum and keep the burned area aseptic if some other form of treatment is used before the tannic acid is applied. I feel that here, as in many other places in surgery, it is the man who first sees the patient and applies the first treatment who determines the ultimate outcome in that particular case.

Discussion:

DR. MATHEW A. TINLEY, Council Bluffs, Iowa: Dr. Montgomery has given not only a very able paper on personal experience but also a complete review of all that is most recent on the treatment of burns. His closing statement is so patently true that it needs no comment.

The ultimate outcome in a final stage of a burn is dependent upon the type of treatment by the one first seen. Dr. Montgomery mentioned the home remedies that are used. The remedy that is of the least possible harm is bicarbonate of soda. We know that in homes a grease of some type is almost always applied. Each household has some remedy or ointment that they feel is very valuable. In a factory there may be a jar of grease near which has been open for months and is an ideal medium upon which bacteria may thrive and grow.

Dr. Montgomery summed it all up very well when he said it was a question of primary saving of life, reducing the suffering, preventing so far as possible contractures and limiting the amount of scar, maintaining the water and chloride balance. When some of the home remedies have been used it becomes necessary to cleanse the wound. I have used a combination of peroxide and green soap.

I agree with those who decry the intense debridement of the wound, damaging what otherwise might be tissue that would repair. I would further call to your attention the mistake that many of you make in your first opinion of the extent of damage by the burning. It is too easy to believe that it is a very slight primary burn and then have to report that there are present numerous areas of a third degree burn with destruction of the deeper tissue. The patient must be informed that he has a burn that is fairly extensive and the amount of damage done cannot be determined for a day or two. We know that the first great danger point is the first 24 hours. There may be shock from the damage done and sometimes intense loss of fluid. Dressings are very important. I have had the experience of finding my eschar very deep and tense and adherent and indicating an area that had been infected beneath it, and this has required removal of a portion of eschar, which was mighty difficult. I have had very good results with the use of narrow straps of adhesive in burns of limited area where the eschar did not form promptly. By leaving it open between the strips of adhesive this made a comfortable dressing, did not tear up any newly formed skin, and left but little scar.

I learned something interesting recently that happened in a CCC camp. There was a bad fire there and many men lost their lives because they did not know that the proper position to take in such a condition is prone on the ground with the face covered. Some 40 of these men came out all right and alive but with very bad burns.

It has been said that the ideal burn treatment is: first, make the patient comfortable; second, save the life; third, minimize shock; fourth, prevent absorption of toxins;

* In *Arch. Surg.*

fifth, prevent loss of chlorides, prevent infection; and last, be simple and inexpensive.

DR. ALBERT H. MONTGOMERY, Chicago (in closing): I want to thank Dr. Tinley for his very kind discussion. He has added considerably to my paper. The question of checker-boarding of a burn has been advocated and I think it has merit. I would call your attention particularly to the use of a constricting dressing where the burn completely circumscribes a part like the arm or the leg. I think it is important to put at least one strap in to break the tension so that the constriction will not affect the circulation.

There are many things in the treatment of burns in regard to the use of grease, etc., which we have to encounter, and often what has been used as a first aid agent makes the following treatment much more difficult.

Advantages of Surgery

—*in Pulmonary Tuberculosis*—

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TUBERCULOSIS is a chronic systemic disease with a decided tendency to heal. Were it not for this fact the human race would long since have vanished.*

The treatment of pulmonary tuberculosis, cognizant of this chronicity and tendency to spontaneous healing, is based upon the time-tried-and-proven principles of rest, fresh air and wholesome food. In the modern treatment of pulmonary tuberculosis active or aggressive surgical measures designed to secure local rest, relaxation or compression of cavities have been added.

Rest to be efficient, must be physical or general, physiological, or local and psychic. It must be as absolute, as tenable, as prolonged as progress of the lesion demands, and most important, it must be timely.

When tuberculosis becomes clinically manifest the earlier the triad of rest, fresh air and wholesome food is instituted, and the more consistently it is enforced, the more rapid and certain will be resolution.

Notwithstanding the inherent tendency to heal, it is expedient to consider tuberculosis more serious than the clinical symptoms indicate and to promptly institute and rigidly pursue appropriate treatment. It is easier to prevent than it is to cure tissue destruction and complications. The patient must be taught the purpose of the proposed routine and the necessity for his whole-hearted cooperation. Without his continuing cooperation and a will to get well no treatment can be fully effective.

The therapeutic result will be proportionate to the degree and duration of the rest attained. This is true not only in the earlier stages of the disease but also in the advanced stages, and in those cases which have failed to respond to the usual passive or expectant treatment and require active or aggressive treatment with some form of surgical aid to establish a favorable balance of resistance against the progress of the disease.

Early diagnosis is a prime requisite to success in the treatment of pulmonary tuberculosis. It is not always easy. Infection with the tubercle bacillus usually takes place in early childhood. Small or repeated doses of TB infection raise the resistance to such a degree that it may remain dormant throughout a long active life. Tuberculosis is commonly activated by an acute illness, improper or unbalanced diet, in adolescence and young adults by exposures, recurring colds, bronchitis, grippe, influenza, pneumonia, and excesses of all kinds—particularly in devotees of Bacchus, Venus and Mammon.

It is axiomatic that in all pulmonary diseases, from the insidious through the very acute to the chronic forms, the presence of pulmonary tuberculosis must be considered a probability which should be verified by repeated physical examinations and x-ray studies of the lungs.

The physician who is tuberculosis-minded will habitually detect the presence of pulmonary tuberculosis much earlier, at a time when most can be accomplished by expectant measures.

Every patient differs in his general and local reaction to infection. The dose, and the degree of virulence of the infecting organism and the grade of his susceptibility, which fluctuate from time to time, determine the course, the clinical symptoms, the character and the intensity of the pathological changes. Allergy and local tissue resistance are also important though little understood factors.

The response of each individual to therapy likewise varies. Every case must be treated as an entity. No inflexible rule can be made for all cases. Each procedure must be designed to fit the patient, not to fit the patient to the procedure.

Every patient who presents indications for the more radical procedures of surgical collapse is a living example of failure: a failure of the patient to seek timely, competent medical aid; a failure of the physician to diagnose the case early or to appreciate the gravity of the disease; a failure to institute promptly and to continue rigidly appropriate conservative measures; a failure of the patient to accept the advice of, and to conscientiously cooperate with, his physician; a failure of the disease to respond to expectant treatment; a failure to resort early to less radical measures for collapse therapy.

Early diagnosis, early general rest, early local rest secured by early pneumothorax, early interruption of phrenic nerve conduction and early surgical collapse mean early resolution. There is an optimum time for each form of therapy. A favorable opportunity lost renders general conditions more serious and local lesions intractable.

General rest and expectant treatment should be tried for a reasonable time—a period expressed in terms of weeks. There are many patients whose lesions can not be controlled by general measures alone, or who for economic, social or temperamental reasons can not be favorably influenced by the usual expectant regimen. Should favorable progress fail or cease, aggressive active measures to secure the additional benefit of local rest exercised

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by collapse therapy are promptly indicated. We must obtain promptly the minimum collapse of the lung that is conducive to healing all the tuberculous infiltration and cavitation.[1] The earlier a focus not controlled by expectant treatment is attacked by the minor measures for collapse therapy, the more certain, rapid and favorable will be the effect and the fewer will be the complications; unnecessary destruction of tissue will be prevented and drastic operations avoided. This is as truly conservative in pulmonary tuberculosis as it is in cancer. Late or delayed operations are always of greater magnitude and danger, and the results are more unsatisfactory, than with early operations.

SURGERY can not eradicate tuberculosis, especially in its pulmonary localization. Surgery is not a substitute for, but a supplement to accepted medical measures when these, after a reasonable trial, have failed to establish a resistance balance against the disease. The all too general tendency to recommend surgical intervention only as a last resort is not giving the patient the best advice. Delay places an unfair burden on surgery. Such patients are sub-standard surgical risks, usually in the advanced or terminal stages of the disease. They are psychically depressed and their vitality is depleted. Other organs are compromised by prolonged toxemia or the tuberculous disease is disseminated to other parts. Notwithstanding, many such patients have been saved and restored to lives of usefulness. Many more could be more promptly restored if surgery were invoked earlier.

The value of surgical compression is no longer a matter of doubt. That it is of inestimable value is an incontrovertible fact demonstrated by successes wherever its limitations and possibilities are thoroughly understood.

The purpose of collapse therapy is to prevent development of restraining mechanical factors or to eliminate the impediments to contraction when they have formed. It is desirable to obtain early and complete closure of all forms of cavities as soon and as safely as possible.[2]

The objective of surgical collapse is to compress cavities and to control the interposed lesions which are inimical to the orderly process of healing. The more selective the collapse, the less will healthy lung tissue be impaired, the less embarrassed the respiratory function, the more satisfactory the immediate effect and the better the final result. Ablation of a greater mass of lung tissue than is absolutely necessary should be avoided. Surgical collapse is irretrievable. A permanent burden is thrust on the remaining lung which nearly always is, or may subsequently become, involved in some degree. One can never foresee the demands that may be made on the remaining lung.

A case of pulmonary tuberculosis demands medical supervision from its inception until it is clinically cured. Too often this fact is overlooked in cases subjected to surgical collapse. The patient, and sometimes his physician, is deluded by the immediate improvement secured by surgical intervention. Frequently they relax in the care which is absolutely necessary to make these benefits permanent. Relapse or irremediable extension may take place. For a lasting cure it is obligatory that the patient continue for months after operation, a graded rest regimen. Adequate prolonged compression facilitates permanent obliteration of cavities and healing of the pericavitary lesion by fibrosis. No operation can do more.

A surgeon should approach a case of pulmonary tuberculosis from a medical no less than from a surgical viewpoint. He should collaborate with the radiologist and the phthisiologist who must become surgically minded. The future of the patient is much safer when he is under the care of men who understand both aspects of his disease.

Before deciding on operative intervention, a careful and complete examination of the patient, a review of his history, a meticulous study of the evolution and the present status of the lesions in the lung so graphically and chronologically recorded by a series of x-ray films is imperative. This information is of inestimable value in deciding what, if any, surgery is indicated.

The procedures for collapse therapy are:

1. ARTIFICIAL PNEUMOTHORAX, unilateral, alternating or simultaneous bilateral.[3]
2. Temporary or permanent INTERRUPTION OF PHRENIC NERVE CONDUCTION.
3. DIRECT or INDIRECT INTRAPLEURAL PNEUMOLYSIS. These are relaxing operations which leave the thoracic wall intact.
4. SCALENIOTOMY.
5. EXTRA-PLEURAL PNEUMOLYSIS with or without filling the extra-pleural space.
6. A PARTIAL UPPER OR LOWER THORACOPLASTY (with or without extra fascial pneumolysis), or
7. COMPLETE THORACOPLASTY, are compressing operations which alter the bony structures of the thoracic wall.

Artificial pneumothorax[4] decreases the volume of the lung by the injection of controlled amounts of air through a needle introduced into a free pleural space. It may be relaxing or mildly compressive. Refills are necessary at more or less regular intervals over a long period of time. Early, continuous, moderate relaxing pneumothorax is a prophylactic pneumothorax. It separates the visceral from the parietal pleura, prevents the early formation of adhesions, relaxes and rests the lung, is conducive to collapse of early soft thin-walled cavities and to the healing of the pericavitary zone and other lesions in the lung. Early pneumothorax is less difficult and of no greater hazard than a later pneumothorax. It may render further measures of collapse therapy unnecessary.

The practice of inducing pneumothorax to rather high degrees of plus pressure in order to secure an increasing degree of compression of the lung, or to attempt attenuation of restraining adhesions, desirable as this may be, frequently causes unpleasant or even serious complications.

When an efficient early pneumothorax is induced and can be continued without lapse for the required length of time, it is the most effective form of collapse. Collapse to be effective must

completely and continuously relax or compress the predominantly diseased area. On account of pleuretic adhesions or obliteration of the pleural space, a pneumothorax can not always be induced or maintained to a degree necessary to relax the diseased or cavity bearing area of the lung. It is not a selective collapse. An incomplete pneumothorax, while it may not collapse a cavity, does exercise a salubrious effect on the pericavitary area, it renders the pleura less sensitive, the mediastinum more rigid and gives the heart and contralateral lung time to become adjusted to the altered intrathoracic pressure. The patient thereby is fortified and will better tolerate more formidable procedures for collapse. These should be instituted without delay. Too prolonged treatment without diminution in the size of cavities, or a continuing improvement of the lesions in the lung is not good therapy. It is a waste of valuable time; it courts complications and withholds other measures when these give assurance of success.

Intrapleural Pneumolysis

CLOSED intra-pleural pneumolysis is the severance of restraining and tethering pleuritic adhesions through a thoracoscope by means of electro cautery or electro coagulation.

In open intrapleural pneumolysis the pleura is opened, the adhesions may be cauterized, coagulated or double ligated and cut. Pleuritic adhesions are the greatest impediment to successful artifiicial pneumothorax. If restraining adhesions are narrow, cord, band or fan shaped and long enough to permit the manipulation of the necessary intrathoracic instruments, they may be severed by intrapleural or closed pneumolysis[5]. Thus may an inefficient or partial pneumothorax be made efficient or complete.

The character of the adhesions, their relation to the tuberculous cavity, to the lung, pericardium, great vessels (especially at the apex) and to the thoracic wall, are of importance not only in the effect they may exercise on keeping the cavity open and the lung expanded, but also in the possible danger of puncturing important structures and the tearing or erosion of a cavity wall or the diseased lung during or subsequent to cautery pneumolysis.

The type, number and character of adhesions cannot be accurately determined by x-ray study. The thoracoscope is of positive value in the study of intrapleural adhesions. The restraining effect of adhesions must be established before intrapleural severance is undertaken. The reaction it will induce in the diseased area, the pleura and remainder of the lung, should be estimated. In the apex of the thorax where intrapleural pneumolysis would be most helpful, it is frequently impossible or too dangerous.

Interruption of phrenic nerve conduction may be temporary as in crushing the nerve (phrenic emphraxis) or permanent by cutting (phrenic neurectomy) or avulsion (phrenic exeresis) of four or five inches of the main trunk and all the accessory branches.

The purpose of interruption of phrenic nerve conduction is to paralyze the corresponding hemidiaphragm. A paralyzed diaphragm is entirely passive. Any movement it may have or any position it may assume is dependent upon the relative intrathoracic tension above the diaphragm, as determined by pleuritic adhesions, fluid or air in the pleura space, or dense massive contracting fibrosis within the lung, and the influence of the intra-abdominal press below the diaphragm. Its normal tonus and independent movements are eliminated. The diaphragmatic muscle atrophies and unless held by adhesions in the costophrenic angle, soon begins to rise. The average rise is slightly greater on the right than on the left side. The maximum rise may not be reached for months. The volumetric capacity of the thorax is reduced. Interruption of the phrenic nerve produces continuous uniform relaxation of the lung, more pronounced in the lower than in the upper lobes, without the inconvenience and dangers of pneumothorax refills. It places the lung in a state of partial rest.

Phrenic nerve operations are not, and never were intended to be, complete or curative operations. Collapse and healing of cavities does occasionally ensue. Improvement in the lung and the general condition of the patient is striking. The cough diminishes 30 to 50%; expectoration is easier and decreases rapidly. This improvement is, as a rule, temporary. Many a favorable opportunity is wasted and much of the patient's valuable time is lost by not taking advantage of this temporary gain. Artificial pneumothorax may be made more efficient and more selective, or may be rendered unnecessary; intrapleural pneumolysis, and more drastic extensive compressing operations avoided by early phrenic nerve interruption.

Scaleniotomy is an operation in which the scalene muscles, anticus, medius and posticus are severed close to their insertions on the first and second ribs.[6] This eliminates the action of the scalene muscles on the upper two ribs and secondarily limits the action of the upper four intercostal muscles. The raising and horizontal rotating action of the upper ribs is stopped. The transverse diameter of the upper thorax is somewhat reduced; the apex of the lung is relaxed and placed at partial rest. These effects are usually inadequate, often negligible. A scaleniotomy may be performed through the same incision at the time of a phrenic nerve operation, or sometime later to augment the effect of the phrenic nerve paralysis.

Extra-pleural pneumolysis, termed apicolysis when limited to the apex of the lung, is an operation by which a cavity and its circumscribing area are actively compressed. A sub-periosteal resection of a short segment of the rib overlying the cavity is performed. The periosteal bed is incised. Through this opening, by blunt and finger dissection, the endothoracic fascia overlying the cavity is separated from the inner surface of the thoracic wall. The resulting subcostal space is usually filled with some material — paraffin, fat, muscle, gauze or a pneumatic bag to maintain compres-

sion. No foreign material is entirely satisfactory. Extra-pleural pneumolysis attains an immediate highly selective compression. Were it not for a number of disadvantages it would be ideal. It is not always continuously efficient, is uncertain in its delayed effect and only slightly, if at all, less serious than a limited thoracoplasty.

Extra-pleural pneumolysis has an important field and no other procedure can approach its effectiveness in compressing residual cavities in the costovertebral groove which a corrective or revision operation has failed to close.

Thoracoplasty is the sub-periosteal resection of entire or definite lengths of a number of ribs to secure active compression of cavities in a diseased lung area. It may be partial, limited to the upper or lower ribs, or complete, including all the ribs to the eleventh or twelfth. A complete thoracoplasty in *one* stage is most effective and uniform in its compression. It is massive, not selective compression. The mortality is prohibitive. This excessive mortality has led to performing multiple stage operations, resecting a few ribs in each stage.[7] This reduced the mortality and extended the field of surgical compression to include the greatly debilitated patients.

Total or subtotal resection of the upper four ribs produces a great and decidedly selective compression on the upper lobe. The lower lobe is not materially affected.[8] Total or subtotal resection of the lower ribs as a first stage without extra-fascial compression is not very satisfactory. An upper partial thoracaplasty may be combined with extra-fascial pneumolysis after the method of Semb in carefully selected cases.[9,10]

The collapsing effect of rib resection depends not so much on the length of the segments removed as on the shortness of the remaining stumps. Posteriorly the resection must extend to the transverse spinous process which may also be resected. The number and lengths of rib segments to be resected is determined by the character, extent and localization of the disease in the lung, the stability of the mediastinum, the thickness of the pleura, the conformation and rigidity of the chest wall.

Parsimonious rib resection secures only partial collapse, leaves uncollapsed residual cavities which demand secondary operations, lateral costectomy,[7] anterior costectomy, or difficultly corrective operations with or without extra-fascial pneumolysis.

When all efforts to close residual cavities have failed, open drainage is indicated. The periodicity of obstruction to bronchial drainage, the duration and severity of the constitutional toxic symptoms caused by a blocking and absorption of toxins from the closed cavity must be balanced against the inconvenience of a prolonged and possibly a permanent fistula.

The indications for thoracoplasty are practically the same as for pneumothorax, when this can not be induced or continued or becomes unsatisfactory. After other less drastic relaxing and compression measures have been tried and failed or by reason of the nature of the lesion, empyema, tuberculosis or mixed, bronchopleural fistula bronchectasis, cardiac compression, they are destined to prove inefficient.

The contralateral lung must be capable of maintaining the respiratory functions and must be free of active or acute exudative lesions. Old chronic inactive or low grade foci in the opposite upper lobe, near the apex with or without cavitation are not contra-indications. Active, fresh, recent lesions especially near the base, severe asthma, emphysema, an active or decompensated diseased heart, uncontrolled diabetes, severe disease of the kidneys, are absolute contra-indications. Tuberculosis of other organs according to the extent and degree of activity are unfavorable complications which prejudice, but do not exclude, surgical collapse. Severe anemia, low hemoglobin, a persistently high temperature and rapid pulse, very low blood pressure are indications of a seriously compromised vital reserve. The condition of the cardiac vascular system, especially the myocardial reserve, is most difficult and important to evaluate. Since most of the operative, many postoperative and some of the delayed deaths are directly or indirectly associated with myocardial deficiency it is imperative not to overtax the heart by attempting too much in any one stage. Far better to regret doing too little and have the patient react well than attempt too much and have the patient die.

References:

1. DUNDEE, J. C.: End treatment of artificial pneumothorax; new use of phrenic avulsion, *Am. Rev. Tuberc.*, 25:469, 1932.

2. O'BRIEN, E. J.: Suspended cavity in pulmonary tuberculosis, *J. Thoracic Surg.*, 1:603, 1932.

3. CUTLER, J. W.: Clinical types of therapeutic pneumothorax and their significance, *J.A.M.A.*, 103:81, 1934.

4. POTAIN, M.: Des infections intropleurales de Fair Sterilisé dans le traitement des epanchements pleuraux consecutives au pneumothorax, *Bull. Acad. de Med.*, 19: 537, 1888. ALEXANDER, J.: Surgery of Pulmonary Tuberculosis, Lea and Febiger, 1925.

5. JACOBAENS, H. C.: The cauterization of adhesions in artificial pneumothorax treatment of pulmonary tuberculosis, *Am. Rev. Tuberc.*, 6:871, 1922. Cauterization of adhesions in pneumothorax treatment of tuberculosis, *Surg., Gynec. & Obst.*, 33:493, 1921.

6. GALE, J. W. and MIDDLETOWN, W. S.: Scaleniotomy in surgical treatment of pulmonary tuberculosis, *Arch. Surg.*, 23:38, 1931.

7. HEDBLOOM, C.: Anterolateral costectomy for inadequate collapse following posterior extra-pleural thoracoplasty, *Arch. Surg.*, 21:1114, 1930.

8. ALEXANDER, J.: Special considerations relating to surgical closure of large upper lobe tuberculous cavities, *J. Thoracic Surg.*, 12:1, 1932.

9. SEMB: Thoracoplasty with extra-fascial apicolysis, *Acta. chir. scandinav.*, Supp. 37, art. 2-76-1-85, 1937.

10. OVERHOLT, RICHARD: Thoracoplasty with lung mobilization, *Am. Rev. Tuberc.*, 35:4, (April) 1937.

Discussion:

DR. RICHARD M. DAVIDSON, Chicago: We have just listened to an excellent presentation of the subject "The Advantages of Surgery in Pulmonary Tuberculosis" by Dr. Hegner, a man who has been identified with the leaders in the development of the important field of collapse therapy. This paper gives a thorough and concise outline of our modern management of tuberculosis and a clear description of the various collapse measures. It contains many statements of fundamental importance to which I wholly subscribe.

Dr. Hegner mentions the importance of natural resistance of the patient, and truly without this we can

accomplish little. It is true that "surgery does not eradicate the disease," but only puts the lung in a state where it can more successfully overcome the process. The exact reasons for the benefit of collapse are not completely explained, but closure of the cavity is very important. Dr. Hegner's statement, "it is desirable to obtain early and complete closure of cavities as soon as possible," cannot be over-emphasized.

The words "interruption of the phrenic nerve is not a complete or curative operation" are timely for there is, I feel, too much of a tendency to procrastinate with this simple procedure, when pneumothorax fails, when the more positive thoracoplasty should be called into force.

Dr. Hegner speaks of the value of rest and diet and a trial of rest and expectant treatment. These are undoubtedly important, but I feel that it is of far more importance to obtain and maintain a satisfactory collapse, and many of our cases have been carried along with excellent results by ambulatory treatment and little or no interruption of their usual activities.

Dr. Hegner mentions the importance of early diagnosis, and this is what we are striving for. However, we are now quite convinced that early tuberculosis most frequently causes no recognizable symptoms of physical findings and the early case can be found only by x-raying apparently healthy tuberculin positive individuals.

Collapse therapy is the most important point in the treatment of pulmonary tuberculosis and one of the most important medical advances of this period. The treatment has a further reaching benefit than to the individual himself, in that many become negative cases and no longer a source of infection to others. When every open case can be isolated or closed, there will be no more tuberculosis.

By far the most important collapse measures are pneumothorax and thoracoplasty.

Again let me congratulate Dr. Hegner on his fine presentation.

Injuries and Disabilities of the Spine

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I SHALL talk about some of the injuries and disabilities of the spine, leaving out a very large number of them.*

First and most important, probably, are fractures and dislocations of the spine caused by injury. The first thing to do, if you see an injured man who cannot move his legs and is evidently paralyzed, is to suspect that there is a fracture of the spine with injury to the cord, and he must be transported immediately. How is this done? Ordinarily a couple of interested bystanders come over, bend the patient up and stick him in the back of a sedan, and take him to the hospital. That, of course, is exactly the thing not to do. No patient with fracture of the spine should have his spine flexed more than at the time he is first seen, because most of such fractures occur by flexion of the spine and flexing them still farther forward may cause damage to the spine which cannot be repaired. The thing to do is to get a blanket, rug, or something similar, put the patient face down on it, and have several men carry him loosely in this rug or blanket so that his spine will be extended rather than flexed. After the patient has been placed face down on the rug he should be taken immediately to a hospital where competent attention can be given. We then have to determine whether this is a complete lesion of the spinal cord or not.

If the cord has been completely cut, he will have no reflexes whatever. He will have no power to move his toes or legs, and in the presence of a manifestly complete lesion of the spine it is probably not wise to advise an immediate laminectomy. If, however, there is some reflex action and it is evident that only a considerable portion of the spinal cord has been injured, it is wise to do a laminectomy, not because there may be hemorrhage into the canal but because there may be pieces of broken laminae or spinous processes crushed into the dural region and making pressure on the cord. So I feel that in the presence of severe spinal cord injury with still some conduction, it is wise to perform laminectomy to remove possible pressure on the cord. Sometimes we are unable to find any actual bone pressing upon the cord in these cases. I have been unable to find any direct pressure in several cases, but we must remember that laminectomy is not a dangerous operation. In many cases it can be performed under local anesthesia with little danger to the patient and with the possibility, however remote, of doing the patient some good.

If laminectomy is not advisable, or even after it has been done, it is wise to place the patient on a fracture bed, make traction upon the head and possibly the hips, although, in complete paralysis, traction on the pelvis often produces decubitus pressure sores because there is no nerve supply to the skin. It is better to tip up the head of the bed five to eight inches and put traction on the chin and occiput rather than making the traction on the legs and pelvis.

Some cases have a surprising amount of displacement and dislocation with the fracture which we would like to manipulate; but very few of us have the courage to try to manipulate these broken backs, although undoubtedly it would be a very helpful measure. We, therefore, prefer to put traction upon the head. In a case where there is a good deal of dislocation, you cannot get enough pull upon the head by the ordinary halter or sling to reduce the dislocation. In the last two or three years certain men have been boring holes in the parietal region and putting wires on each side of the skull to be connected with a cross bar and weight and pulley, and you can get 20 pounds of pull very easily and comfortably by that method.

The general care of the patient with fracture of the spine involving the cord is ordinarily a problem for the genito-urinary surgeon rather than for the orthopedist or the general man, because the management of the bladder complications is, I think, quite highly specialized. I am entirely in the dark as to whether it is better to have the bladder fill up and overflow or whether a permanent catheter should be inserted. So I have a good genito-urinary man come in and take care of that.

Fractures of the spine tend to heal themselves if they have a chance. It is perfectly surprising to

* An extemporaneous address before the American Association of Railway Surgeons, Chicago, September 21, 1937.

see how firmly a fractured spine will become united if too much strain and movement are not allowed. In some of the cases we find that fractured vertebrae have ankylosed together in as short a time as two months.

THE compression fractures of the spine which have not involved the cord represent a different class. When the spine has been compressed forward and the rim of the vertebra has been cracked, almost all the supporting power of the body of that vertebra has been destroyed. Ordinarily we see a forward compression with a wedge-shaped vertebra, and, if we see it early, the problem comes up as to whether we should try to reduce it or should leave it alone. Now, under the more modern ideas, we are advised to put the patient on a hammock and let the hammock sag forward, or rest the shoulders on one table and the hips on another and let the body sag forward, to open up the compressed part of the vertebra. For a number of years this has been advocated by a great many competent surgeons. We have to remember, however, that when we open up this space in the middle of the fractured vertebra, a lot of strong bone has to grow in there before this vertebra will stand much weight, and in the early days some mistakes were made in the after-treatment of these cases. The fracture was reduced and the patient was allowed to get up and walk very soon after the reduction of the fracture. I think Boehler was one of the first and most ardent advocates of early mobilization of these spines after they had been reduced. As time went on we saw more and more of these patients with good reductions for a few weeks after manipulation had reduced the compression, and then a few months later, after these patients had been walking around and carrying weights on their heads, they began to find that the x-ray showed these vertebrae had gone back to the original compression deformity. It takes four or five or six months for the gap in a fractured vertebra to fill up with bone that is strong enough to bear weight. Do not get these patients up in plaster jackets with the idea that the spine is composed of two rigid levers and that by pushing one back sufficiently the jacket will hold it in the ideal position, because the spine is not composed of two rigid levers. It is composed of many little bones that are freely movable even inside the best plaster cast we can put on.

If you adopt the method of trying to get these patients about and back to work again as soon as possible after you have reduced the fracture you will be disappointed, just as I and many of my friends have been, when you look at the x-ray five or six months later.

On the other hand, if it has done no damage to the cord, if you allow the vertebra to remain crushed down upon itself so that the hard cortical borders of the vertebra anteriorly will rest against each other, they will very rapidly grow together and become solid. The patient will have a little kyphosis but he will have a strong spine which may cause no more difficulty. So it is important to make up your mind whether you want to get the patient well in the shortest possible time and you will let it stay the way it was and let him get well in eight to 10 weeks and be able to go back to work with a small kyphos at the site of the injury, or whether you want to do something more radical and requiring more time.

Once in a while a condition occurs in these compression injuries which we call Kümmel's disease. It is not a disease; it is softening or aseptic necrosis of the body of the vertebra. Fortunately it occurs very seldom. It results in more of a kyphos and more destruction of the body of the vertebra than ordinarily occurs in compression fractures. I have seen so few cases that I disregard it in my prognosis of the case, as a general rule. After the appearance of such a condition as this aseptic necrosis or Kümmel's disease, it is wise to keep either a plaster jacket or a back brace upon this spine for a long period of time until the x-ray shows that remineralization of the vertebra has taken place.

Milder types of compression fractures may occur with very slight traumatism. I have seen one in a girl of 19 whose feet slipped out from under her so that she sat down too hard. She had pain in her back and around the ribs, but nobody thought of a compression fracture of the vertebra until some lateral x-ray films were taken. In all these injuries you will find that the lateral x-rays are the most valuable. The anteroposterior view of a compression fracture of the vertebra may not show very much, but carefully made lateral x-rays may reveal definite compression.

I have also seen this fracture occur in an individual who went over a bump in a taxicab and struck the top of the car. On examination it was found that one of the vertebrae had been compressed. In elderly people it is extremely common and very easy to produce such a fracture, because in many older people the bones of the spine are demineralized to such an extent that not one but several fractures may occur with very little apparent cause.

At different levels there may be different sets of symptoms. We had a woman of 52 who was sitting at a table and turned suddenly to the left and felt pain in the eleventh and twelfth ribs; she was not disabled. The pain was rather sharp, and she went to a hospital and was seen by a good surgeon who had some x-ray films made which went as far as the twelfth dorsal vertebra and then down to the sacrum. These showed a fracture of the second lumbar vertebra and another fracture below. But this did not explain the pain at the level of the eleventh segment, so another x-ray film was taken which showed that the eleventh dorsal vertebra had also been fractured. So this woman had three compression fractures in the spine at the age of 52 without much decalcification of the vertebrae. She has been investigated as to calcium output and as to the possibility of parathyroid tumor, but the calcium output is normal and there is no evidence of a parathyroid tumor. In a simple

Taylor brace she will make a good recovery because she has no cord symptoms except for pain in the eleventh intercostal nerve which undoubtedly is a radicular pain. I have advised her simply to wear the brace and have expressed the opinion that she will get along comfortably.

We had another patient, a man of 74, who climbed a cherry tree and fell down upon his seat, got up, and walked into the house and said his back was rather lame. In a few days he had a little pain low down, but he was very active and went about for some weeks until his son persuaded him to go to a doctor and have an x-ray taken. He has a fracture of the fourth lumbar vertebra and the first lumbar. In addition to that he has this peculiar condition of the lumbosacral joint: there is a large outgrowth on the upper part of the first sacral vertebra and a mass on the lower part of the fifth lumbar. Because he has some sciatic pain it was proposed to try to hyperextend the spine and see if these vertebrae could be straightened out and made normal in height, but when it was explained that this would open up a gap that would require from four to six months recumbency for a part of the time, and a plaster cast, the patient said that he did not mind the pain in the leg and would go as he was. He did consent to wearing a brace and is now going about with the brace, in good condition.

We have also had a patient, a brakeman, who eight years ago began to have pain in the back, which was severe, but he continued to work year after year and after a while the pain disappeared. He remained humped over, because when the doctor made a very good Taylor brace for him he did not like the pull of the straps against the front of his chest, so he threw it away. As the months went by he became bent farther over until finally the whole inflammatory process stopped. He is an able-bodied, strong man with a perfectly solid ankylosed spine. Why such a severe, acute osteoarthritis should appear in the vertebrae alone is a most interesting problem. All of the other joints are perfectly normal. His arms and legs are just as good as anyone's and he can do an average day's work. Many patients with this Marie-Strümpell spondylitis become bent over so that the spine is almost at a right angle to the long axis of the body, unless carefully treated with a back brace. Usually no definite infectious origin can be determined, but in a few instances the gonococcus was apparently responsible.

Discussion:

DR. JAMES E. M. THOMSON, Lincoln, Nebraska: I have always felt that it behooves most of us in treating these cases to get a reduction of these fractures, if possible, first because of the fact that if you have a good reduction of the fracture you have a pretty good talking point with respect to the man's ultimate disability. If he has a poor reduction, his lawyer or somebody else may get hold of him and they will decide that since the x-ray does not look good he has a terrible disability. So we should attempt reduction in most of these cases. There is a personal equation that must be considered with respect to the type of treatment employed. In those men who are living a sedentary life in which it is not necessary to use their backs as laborers, the more conservative treatment can be applied.

With regard to laminectomy, I have always felt that that was quite a serious operation. Perhaps it is, in my hands. Nevertheless, the mortality in fractured spines treated by laminectomy is rather high and the outcome problematical. For that reason I have always relied on the Queckenstedt test for block to determine whether laminectomy was advisable. I have, however, noticed that in a few cases, even though there is partial paralysis and evidence of injury to the cord without complete paralysis, after hyperextension reduction of the spine and immobilization in a plaster cast the paralysis will disappear —perhaps not all at once but gradually—and you can recognize it.

The urologists have convinced me that suprapubic cystotomy in those cases where there is complete paralysis is an advisable procedure. That is not a serious operation, and it does aid greatly in preventing the intoxication which so often occurs with this complicating condition.

I cannot help but emphasize the fact that long periods of recumbence, particularly after reduction, are absolutely essential. You cannot depend upon x-rays or the appearance of the vertebrae because there is relatively little callus that can be evidenced during healing process. Therefore, it is very essential that weight bearing be prevented during the healing period.

The time is certainly at hand when not only doctors should be aware of the proper method of handling these cases at the time of injury but also the layman must be impressed with the danger that occurs from the results of crude handling of these patients after injury. It is my impression that many of these cases may be injured further by being rolled around a good deal after they reach the hospital. I have seen many cases brought to the hospital in the prone position; they are lifted from the ambulance cart and put to bed for an hour or so and then taken to x-ray, lifted out of bed and rolled down to the x-ray, then rolled and rolled some more before they finally diagnose a severe injury. I think the prone position should continue from the time the patient is taken to the hospital until a permanent treatment is instituted.

DR. D. F. FITZPATRICK, Iowa City, Iowa: I wish to congratulate Dr. Ryerson on his wonderful address. There are a few points which might be made in regard to a fracture of the spine. We usually get a fracture of the lumbar spine by the individual falling in a jackknife position, thus forcing the body of the vertebrae forward. In handling these individuals from the time that we get them until they are in the hospital it should be remembered to keep them always in a hyper-extended position.

We industrial surgeons do not feel that where we have a cancellous bone—unless there is too much separation—it will take from four to six months until the individual is about. Rather, the individual should be back in the service at the end of three months. Some orthopedists, who treat these cases by the use of the halter or wires, fastened to some appliance, which have been put through the outer table of the skull in order to produce hyperextension, or by putting on a plaster cast which will extend down below the knees, thus preventing the use of the lower extremities, will find that older patients especially are prone to develop a necrosis. We should all try to prevent the possibility of necrosis. From a psychological standpoint we try to impress upon these patients that they are going to get well and carry on their usual vocation.

In fractures of the lumbar vertebrae with one body pressed forward it has been my practice to apply a heavy plaster cast with the patient in a hyperextended position. This cast will extend from the brim of the pelvis up under the shoulders. The patient is then put on a bed with the boards running lengthwise and not crosswise, and should be on a hard mattress. I then have an apparatus at the head of the bed in the form of a trapeze. The patient in grabbing hold of this with his hands can move himself from side to side and his legs, not being bound down by the cast, he can kick around—lessening the possibility of the individual becoming nervous and think-

ing that he is in a vise. In this way the patient does not feel that the injury is such that it is going to be incurable. I think when you put an individual, for instance an engineer, brakeman, or fireman, who has jumped from his engine or who has fallen off a car in a jack-knife position and fractured his lumbar vertebrae, up in an extended position such as the Doctor has described, in all probability the company will have a lawsuit on their hands before they are through with the case.

When you come to a fracture of the dorsal spine you have a different proposition to deal with because you usually have a lateral displacement of the vertebrae. If upon examination I find these individuals have only a spastic paralysis instead of a complete paralysis, I usually put them on a Bradford frame for a certain length of time and after the spasticity has cleared up, I then put them in a plaster cast that extends from the neck down to the brim of the pelvis or just below the brim of the pelvis. After a few days this cast is split on either side so the patient's position can be changed, allowing him first to lie on his back and then on his stomach. You never get a perfect result, and these patients usually have a permanent deformity of the spine. However, the end results are good and the patient is back on his feet within a short time. After the removal of the cast we then use a commercial splint which the patient may wear for a year or more.

Keeping patients down in bed for four or six months with this type of injury seems to me not necessary because the cancellous bones heal very readily, and when we have a fracture of the dorsal vertebrae the patient is carrying that part of the body from the head down to the point of fracture, which is much less than if he were carrying the weight of the whole body on a recently fractured thigh.

Fractures of the Transverse Processes of the Lumbar Vertebrae

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FRACTURES of the transverse processes of the lumbar vertebrae will be considered in this paper.* Fractures of the transverse process of the cervical vertebrae seldom occur uncomplicated by fractures elsewhere in the vertebrae. In the dorsal spine the ribs help to protect the transverse processes and uncomplicated fractures seldom occur here. It is found that most of the fractures of the transverse processes in the lumbar region also occur as a complication of more serious injuries to the bodies and to posterior portions of the vertebrae. This is especially true in industries such as coal mines from which many of the cases here presented are taken.

It was found in a study of the State of West Virginia Compensation files that uncomplicated fractures of the transverse processes occur only once out of each 70 spine injuries reported, including sprains and fractures. It was possible, however, to find 27 uncomplicated by other spine fractures. It is thought that it might be of some interest to analyze these cases, particularly regarding the methods of treatment used and the length of disability.

First, however, let us discuss briefly the mode of injuries in these cases—i.e., whether indirect, through the muscular action of the ilio-psoas or the quadratus lumborum group, by direct blows on the transverse processes themselves, or by muscular action combined with a direct blow, as in the case of a direct trauma with the spine flexed.

In this series of 27 cases, 23 were undoubtedly due to direct trauma, one was undoubtedly due to indirect trauma, and three were due to combined direct and indirect trauma.

Most of the injuries in this series were due to slate falls or to the man being caught between objects in the coal mine, i.e., direct trauma. Most authorities state that these fractures may be due to the various modes of trauma which were previously discussed. Boehler states, however, that these fractures are rarely due to direct trauma. It is believed by the author, however, that most of these cases are due to direct trauma.

These fractures often occur after severe trauma. Six of the 27 cases were complicated by injuries elsewhere than in the spine; one case involved the pelvis and ribs; one the pelvis and right femur; two the pelvis alone; one a leg injury, and one a foot injury. This again shows the importance of complete general examinations in all cases, as we know that spine injuries are frequently missed.

It might be well to consider here very briefly the signs and symptoms in these cases. Marked, well localized tenderness is present over the affected process or processes. This is always present. This tenderness is much better localized than it is in acute back strains alone. However, it must be remembered that most of these fractures are associated with ligamentous strains and with contusions and hematoma of the back muscles. Of course, no deformity of the back is found. All motions of the back, especially attempted flexion, are limited by pain and muscle spasm. Key and Conwell, Wilson and Cochrane, and others, point out also that flexion of the hip on the affected side against resistance is painful. Also passive hyperextension of the hip on the affected side is painful. At times abdominal distention and tenderness are found. This is considered by DeCoulx and Patoir to be due to retroperitoneal hemorrhage. Naturally, this is less frequently present than in fractures of the bodies of the vertebrae.

As Osgood so aptly says in his discussion of fractures of the vertebrae, suspicion is the key to diagnosis in these cases, and suspicion naturally leads to an x-ray examination. It is the anteroposterior view that discloses the fractures. Of course, the lateral view and frequently the oblique views are taken also to make sure that other fractures are not missed. However, we must avoid if possible the pitfalls that arise as the result of incorrect x-ray interpretations. According to Wilson and Cochran, the following are sources of error and lead to mistaken diagnoses of fractures:

1. Old ununited fractures of the transverse processes;

2. Asymmetry of the axes of the corresponding transverse processes on the two sides;

3. Shadows of the psoas muscle may appear to be fractures;

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* Read before the Congress of Railway Surgeons, September 21, 1937, Chicago.

4. Rudimentary ribs of the first lumbar vertebra may seem to be fractures.

Now an actual fracture usually occurs in the middle of the process. It is usually irregular, sharply defined and may be more or less displaced. The displacement is usually downward and outward when it is present.

In this series, 22 out of 27 cases showed multiple fractures of the transverse processes. The second, third and fourth transverse processes were involved most frequently. In four instances as many as four transverse processes were involved. There seemed to be no relationship between the number of processes involved and the mode of injury, nor between the number involved and the prognosis.

The question of treatment of these cases is most important. It is agreed by all that it is essential, especially if the accident occurs in industry or if any liability is involved, that the injured have the correct impression regarding the type of injury that he has sustained. It should be emphasized that he has only a fracture of a small process of the vertebra which serves simply as an attachment of the muscles. It should be emphasized also that he does not have a "broken back" in the ordinary lay use of the term. However, I do not believe it is wise to conceal from the patient altogether the fact that there is a fracture. This might conceivably result in a lawsuit if the patient found out later himself that he did have a fracture. However, we know that the correct mental attitude toward the injury is the most important single factor in getting the man back to work within a reasonable length of time.

On the other hand, there is no general agreement as to the other steps in the treatment. Boehler believes that the only treatment necessary is rest in bed for from one to three weeks, with hot air or hot applications, or massage. DeCoulx and Patoir advise recumbency for from three to four weeks and state positively that no plaster jackets or supports should be used. Wilson and Cochrane, also Key and Conwell, advise the combined methods of recumbency of three to four weeks with physiotherapy, followed in many cases by strapping or plaster of Paris jackets for from two to five weeks. It is emphasized, however, by them, that treatment must be individualized as far as possible, also that under-treatment rather than over-treatment is to be desired if anything.

It is recognized that these fractures of the transverse processes do not always unite by bony union. Quaintance states that in his series of 33 cases, non-union occurred in 18%. However, he believes that this has little if any relationship to the severity of the symptoms. He and others advise strongly against operative interference in non-union. However, Hartwell operated on five cases with the symptoms relieved in each case. It is believed by the author that operation is never necessary, even in the event that there is non-union.

In this series of 27 cases, bony union failed to occur in three (11%). Temporary disability varied from 120 to 180 days in these cases, and there was no permanent disability in two cases and 5% in the third case.

An attempt was made to determine the relationship between the various methods of treatment and the temporary and permanent disability. There was a period of rest in bed, lasting for one week to six or eight weeks, in all cases. In some cases, physiotherapy was used.

The variations in treatment came when the patient was allowed to be up and about. In nine cases plaster jackets were applied. The period of temporary disability varied from 39 to 483 days with an average of 172 days. The temporary disability was usually around 120 days. No permanent disability was present in six of the nine cases. Five per cent was present in three cases.

After the patient got up and about, adhesive strapping was used in eight cases. The period of disability in these cases varied from 37 to 237 days, with an average of 123 days. The disability was usually around 120 days. There was no permanent disability in seven of these cases and 5% in one.

In eight cases no retentive apparatus was used when the patient became ambulatory. The period of disability here varied from above 51 days, with an average of 213 days. The disability was usually around 120 days.

It would appear from this small series that one cannot lay down any hard and fast rule regarding the proper method of treatment. However, it would seem that the treatment of the soft tissue injuries was more important than the treatment of the fracture itself. That is, if we regard these fractures as sprain fractures and not as simple fractures our treatment will, perhaps, be more intelligent. Therefore, we must take into consideration carefully the amount of contusion and swelling and the amount of ligamentous strain present. All our cases are treated, therefore, largely symptomatically.

However, we do have a routine which is varied according to the circumstances. The patient is always placed on a firm bed with fracture boards used under the mattress. He is kept flat in bed for a period varying from two to four weeks ordinarily. This period depends largely on the presence or absence of arthritic changes as shown in the x-ray picture. When hypertrophic changes are present the period of recumbency is made longer. While he is in bed, hot fomentations or the infrared lamp are used three or four times a day. When the muscle spasm and tenderness have largely disappeared, a well-fitting plaster jacket is applied with the patient recumbent. This should extend from the upper dorsal spine to the sacrum and should be moulded especially well about the hips. Frequently this plaster is split up the front and a lacing applied. It can then be removed for baking and massage. This plaster jacket is left on until eight weeks from the time of the injury, i.e., from two to four weeks from the time of its application. During all this period he is encouraged to walk about and to take routine back and leg exercises. At the end of 70 to 84 days it is believed that the man should be able to return to light work. An effort is made to have the employer give him light work for another 14 to 28 days in order to avoid the probability of a fresh sprain.

It is understood well that this series is a very small one and that broad conclusions should not be drawn from it. It is hoped that it will stimulate some thought, however, about a type of injury which is considered minor but which frequently leads to long temporary disability with resulting loss to the worker and industry.

Bibliography:

1. KESSLER: Accidental Injuries.
2. KEY and CONWELL: Fractures, Dislocations and Sprains.
3. HARTWELL: *Colorado Med.*, 26:37 (February 1929).
4. QUAINTANCE, P. A.: Fractures of the Transverse Processes of the Lumbar Vertebrae, *Arch. Surg.*, 10:968 (December, 1930).
5. DECOULX and PATOIR: Les fractures des transverses Lombaires, *Rev. d'orthop.*, 23:97-120, 1936.
6. WILSON and COCHRANE: Fractures and Dislocations.
7. BOHLER: Treatment of Fractures.
8. HUNTER, S. J., and OSGOOD, R. B.: Traumatic Lesions of the Axis and Atlas, *Ann. Surg.*, 1910, Vol. 51, p. 193-207.

Discussion:

DR. BENJAMIN V. McCLANAHAN, Galesburg, Illinois: I think we owe Dr. Anderson a great deal for getting together so many little things and presenting them all at once. I think one of the most important things is the list of symptoms of the type of injury which he says is considered minor but which frequently leads to long delayed disability with resulting loss to the patient and to industry. I have been wont to list this injury as a major minor fracture.

I do not know what Dr. Anderson means by sprain fracture and would like to have him explain it, but I know the term broken back means everything from complete severence of the spinal cord on up.

Boehler stated a few cardinal things in the treatment of fracture which will apply often times but they do not all apply here. One is to reduce the fracture, which is impossible in this condition. Another is to put the distal fragment in line with the proximal; that again is not possible. A third is to immobilize, which is not possible, and a fourth cardinal thing is to exercise the part. I think in this type of fracture you can do very little of any of those things. It seems to me that probably the best thing to do is to put the patient to bed, relax the part as much as possible. I like to put my patients on a fracture bed with boards running lengthwise. A great many hospitals run their boards crosswise and I have never found that satisfactory. I think these cases should have some lumbar support, an air cushion or a pillow which will preserve the normal lordosis which occurs in this portion of the spine. Relaxation is essential.

The question of psychology with these patients is often times a question of cooperation. I had not so long ago a pressure injury of the lumbar vertebrae and for the first two weeks I could not get that patient to do anything until I finally got it across that treament was in his hands, and from that time on I had no trouble with him at all. He cooperated in every way, and that is the psychology we need to inculcate in these patients.

DR. JOHN G. FROST, Chicago: My experience with the treatment of simple fractured transverse processes has been that the only treatment necessary is to keep the patient at rest for some seven to 14 days, and I have had patients return to work within the 10-day period. When the injury is more extensive, involving the facets, it is a much more difficult procedure. I feel that the difference is that in most individuals who receive these injuries they have an associated arthritis that lengthens this disability.

Out of 54 x-ray examinations of employees, free from symptoms, the x-rays made of their cervical, dorsal, and lumbar spines, and sacrum and pelvis, showed only five of these spines normal. All of the individuals were under 40 years of age. We find by x-ray many old transverse process fractures where the patient recalls having had no injury to his spine. The psychological effect in transverse process fractures on the party injured is instrumental in shortening the disability. It has been our policy to show them the small transverse process or little rib, as we may call it, and explain that the condition is not at all serious. I feel this aids materially in having them return to their usual work.

DR. RANDOLPH L. ANDERSON, Charleston, West Virginia: My point about sprain fracture was that I feel in my cases that the muscle injury was perhaps more important than the fracture itself because in these cases some of them are associated with muscle strain or muscle contusion at the time of injury and that is what I meant by sprain fracture.

I think Dr. Frost is to be congratulated on getting his men back to work so soon. I wish we could do that. I think if I adopted his method I could probably shorten my disability a great deal.

Fractures of the Pelvis

JAMES J. CALLAHAN, M.D., F.A.C.S.,
Chicago

FROM an anatomical viewpoint the pelvis is formed from union of the ilium and the pubis ischium, these bones uniting to form a cavity, namely the acetabulum.* In turn the two sides are closely and firmly bound together with the sacrum between posteriorly. The many and crossed ligaments that secure the pelvis tend to increase the resistance to severe stress and strains. The entire process forms a true and a false pelvis which contains the various pelvic organs and abdominal viscera. The most important in our consideration is that portion of the genito-urinary system within the pelvis which may be injured by fracture, the descending colon and rectum playing a very important role in fractures of the pelvis on the left side.

The best classification for fractures of the pelvis, in my opinion, is that advocated by Dr. Wm. R. Cubbins:

1. Fractures that involve the ring at:
   (a) One point of circumference.
   (b) Two or more points of circumference with displacement.
   (c) Two or more points with displacement upward of one side.
2. Fractures that involve bones entering the ring with no involvement of the ring:
   (a) Iliac crest; spine of ilium.
   (b) Tuberosity of ischium.
   (c) Sacrum below sacro-iliac joint.
3. Acetabular fractures:
   (a) Involving the brim or cup.
   (b) Involving the three segments.
   (c) Perforating.

NOW in order to fracture the pelvis and have any one of the above, or a combination of them, it is necessary that a great force be applied on the pelvis: some crushing blow, such as an automobile accident, train accident, etc. It might be stated that these fractures are very commonly overlooked, especially in cases of serious injury to other parts. As a matter of fact it is imperative that every person receiving multiple injuries

* Read before Congress of Railway Surgeons, September 22, 1937, Chicago.

be particularly examined for fractures of the pelvis. The most simple type of fractured pelvis is one involving a single ramus, either ascending or descending. These fractures are frequently overlooked because of more serious injuries, or because there has been no disturbance to the bony ring, thus no referred pain, no limp. There may or may not be discoloration or ecchymosis in the perineum. Bladder or rectal complications are exceedingly rare, the only finding being a localized point of pain on pressure over the fracture area and the presence of slight muscle spasm.

The treatment consists of rest in bed with boards under the mattress or between mattresses so as to prevent a sag. No belts, casts, or other means of support or immobilization are necessary. The patient should remain in this position for approximately six weeks and should be able to resume his former occupation in 10 to 12 weeks without permanent disability.

THE next fracture to be considered involves both ascending and descending rami on the one side. These usually present immediate pain and disability with muscle spasm and frequently a rigid abdomen on the involved side. This may be explained by the large retroperitoneal hemorrhage which may even extend to the anterior abdominal wall. With this type of injury it is not uncommon to find urinary complications. So it is advisable in all suspected pelvic fractures to secure a urinary specimen either by having the patient urinate or by catheterization. The latter may be necessary, as some of these patients are in such severe shock that their secretory powers are very low and it may require several hours to accumulate a small amount of urine.

If a small amount of whole blood is recovered one must be particularly suspicious and guided by the depth of the catheter, as it is possible one is dealing with a ruptured urinary bladder. To confirm this diagnosis, some advocate injection of sterile solution into the bladder, noting the amount recovered, or injecting air, with the use of x-ray and fluoroscope. In intraperitoneal rupture, the bladder is usually collapsed because of increased intra-abdominal pressure. In extraperitoneal rupture there is usually bagginess and swelling in the space of Retizus and in the lower abdomen. If the urinary bladder is intact but there has been a rupture of the urethra and it is impossible to introduce a catheter through the urethra into the urinary bladder, (if the patient's condition permits) a suprapubic cystotomy is advisable and the use of Dr. Geo. Davis' sounds is suggested, followed by the introduction of indwelling catheter. Kidney and urethral bleeding must also be considered in the following severe injuries.

The treatment of these fractures is absolute rest in bed similar to that of a single ramus, that is, six weeks, but prolonged in cases complicated by urinary disturbances. The use of a belt for the support of the abdominal organ is recommended. The disability in uncomplicated cases is approximately 12 to 14 weeks.

FRACTURES of both rami bilateral are the result of very severe injuries and are frequently complicated by shock, hemorrhage, ruptured viscera and urinary injuries. There is usually a rigid abdomen, and discoloration of the groin and perineum. Severe pain is usually elicited on examining these patients, especially on compression and spreading of the ileum, and one is to be cautioned not to exert too much force during examination as a sharp spicule may be forced into the bladder or rectum. Rectal examination in these cases requires gentle and skillful manipulation, as the wall may be injured by a spicule causing a tear or perforation, and this will be followed by severe infection and complications.

The treatment is rest in bed and, if the separation is marked, a canvas sling may be used. The most efficient type of sling is one that remains in proper place at all times and has a seat that may be dropped for toilet use. Care must be taken that the sling does not compress the fragments causing them to be forced into the bladder or viscera. It has been my unhappy experience to have this occur, with the presence of blood in the urine for three or four days after the sling had been applied, only to clear up when more conservative form of teatment was instituted. The use of the Bradford frame is beneficial in these cases as it gives the proper support and permits toilet facilities.

The treatment of the above fracture is absolute immobilization in any of the above-mentioned devices for eight to 10 weeks and the subsequent wearing of a belt so that patient may be ambulatory. The deformity in some of these cases may be marked. In males, it usually does not cause permanent disability. In females there may be distortion of the pelvis outlet so as to interfere with pregnancy.

MALGAIGNES fractures are those that involve two horizontal areas, that is, the ascending and descending rami and the ilium or sacro-iliac joint, resulting in marked displacement and elevation on the injured site. These fractures are usually caused by severe trauma, and produce shock, hemorrhage, and shortening of the leg, complicated by injuries to the viscera and urinary bladder resulting in the findings of an acute abdomen. This fracture is much more serious on the left side because of the proximity of the descending colon.

These are treated by traction on both legs so as to immobilize the pelvis or by a Roger Anderson or Carl P. Jones well-leg traction splint. However, the use of the above splints sometimes gives too much rotation and although a good union is secured there is fequently a disproportion that results in permanent disability. Immobilization of the above is approximately 12 weeks and then the use of a belt for support is advocated. Other types of treatment for this condition must include placing the patient on a Hawley table, traction on the injured leg and immobilization in plaster for approximately 12 weeks. It is wise in these cases to check your end result for any slip or dis-

proportion, and this is best accomplished by the use of the Chamberlain technique which requires the weight to be placed on alternate legs and x-rays taken with the aid of a vertical bucky. This will disclose any raise or disproportion in the pelvic arch or ring.

THE second group are those involving the bones that enter into the formation of the ring but not involving the ring. They are usually caused by direct trauma.

In a fracture of the anterior, superior spine, the small fragment is fractured and avulsed causing immediate loss of extension of the leg and flexion of the thigh on the abdomen. The disability is characteristic and the fragment may be palpated and moved freely. There is usually evidence of localized trauma, discoloration, and muscle spasm. These fractures, while rare, may even be compounded.

The treatment is rest in bed in flexion, the knees being bent over a pillow or by breaking the bed to permit flexion at the knee or by having the patient sit up in bed. However, if these do not give the necessary relief and reduction, an open operation may be performed and the fragments replaced. The disability is usually eight to 10 weeks, leaving no permanent loss.

FRACTURES of the wing of the ilium are commonly caused by crushing injuries and are frequently comminuted. Complications are rare unless the descending colon be injured. Delayed or non-unions are frequent in these fractures. The findings are usually those typical of all fractures, that is, muscle spasm, swelling, ecchymosis, crepitus, palpable, painful area over fractured site. Muscle spasm is usually present and there may also be the findings of an acute abdomen.

The treatment is rest in bed and if there is overriding of the fragments use of the Bradford frame or boards between mattresses is advisable. If the separation is wide the use of a canvas sling with strapping of heavy moleskin adhesive tape or a tight scultetus binder may be employed.

The immobilization should require eight to 10 weeks at which time it is advisable that a pelvic belt be employed for further support.

FRACTURES of the tuberosity of the ischium are rare and not commonly found. They usually occur following falls or blows on the buttock. The essential findings are ordinarily those of swelling, hemorrhage, discoloration of the skin, muscle spasm, crepitus, and deformity.

Treatment is rest in bed, and if there is marked separation the use of a sling may be beneficial. The immobilization should continue for eight to 10 weeks.

FRACTURES of the acetabulum are becoming more common, and complicated, and, as it is often said, the complications occurring in these fractures are far more serious than the fracture itself. Up until the last nine years the literature was very meager regarding fractures of the acetabulum, and the cases recorded showed the mortality to be very high. Recent work by Dr. Cubbins, Dr. Scuderi, and myself revealed that if one was on the lookout for these fractures, and cognizant of their complications, the mortality could be reduced. As a result at the Cook County Hospital I cannot recall a single death due to fractured acetabulum with complications. From our study we have divided fractured acetabulum into:

(a) Fractures of the rim;
(b) Fractures of the acetabulum involving one or two of the three bones which form it; and
(c) Perforating fractures.

FRACTURES of the rim of the acetabulum are usually associated with dislocation of the hip; the most common being the posterior dislocation, which pushes out the posterior superior rim of the acetabulum. We have encountered this many times, but we have seen only one bi-lateral posterior dislocation with fracture of the acetabulum.

The treatment is the reduction of the hip, placing the patient on a Hawley table for extension and slight eversion, and applying a body cast. This cast should remain on for 10 to 12 weeks so as to give the acetabulum an opportunity to heal.

The next most common is when the superior rim is fractured and displaced due to an upward force. Usually traction is sufficient for this type, or case—in either case the immobilization must continue for 12 to 14 weeks.

The anterior superior rim is rarely fractured, unless the entire acetabulum is also fractured.

In treatment the dislocation of any of the fragments, if large, should be reduced and immobilized with a screw.

Fractures involving one or two of the three:

These are the ones where we are really called on to make an early diagnosis and render adequate treatment. There is usually severe shock and muscle spasm and flattening over the trochanter, and there may be shortening, but lengthening of the injured side is common.

Treat shock—watch for injury to bladder or abdominal viscera and apply extension, 25 lbs. with Bucks. Later x-ray, and if lateral pull is needed then the most efficient method is to insert a long screw through the greater trochanter in the correct angle of the neck and head and apply lateral traction of 15 lbs. This screw will remain in for about four weeks and will then pull out. This is usually long enough to hold the head out. Continue the longitudinal traction for 12 to 14 weeks. The results have been excellent in our cases. If the ligament teres is intact the displaced portion will be corrected; if not, this fragment may remain displaced inward, but usually causes no damage, and the double traction will hold the head out long enough to permit a new acetabulum to be formed.

The use of the sling in groin has not been satisfactory, as the patient may push the sling down, or adjust it to his own comfort. The use of a Steinman nail or Kirschner wire is almost out of question because it is hard enough to find the greater trochanter and place a screw in it, let alone find-

ing it to insert a wire or pin through it, as it is usually impacted against the ilium.

PERFORATING fractures are those that involve all three bones, namely the ilium, ischium and pubic portions where they all converge to form the cup or cavity. This type is the most difficult to treat as many complications occur—blood vessel or abdominal viscera or bladder or urethra.

The same holds true for these, namely, if the ligament teres holds, then the fragment will come out; otherwise it will remain in.

Treatment is the same, except if condition permits, some of these may be manipulated and cast applied, but the skeletal method is by far the safest and most efficient.

There are some of these that the head remain locked in, or that are old. The best procedure is if the patient is old, leave alone, if young, operate: Fracture the neck of the femur and then externally rotate the shaft and remove head and then replace and secure with flange. Insert screw below for lateral traction. Intra-abdominal correction has been advised.

PROGNOSIS in all fractured pelvis is good. The simpler they are of course the better the prognosis. The subject of pregnancy should be brought up and considered, but I believe it is overrated. Also ruptured bladder or urethra. These are not as common as one would think, considering the many and complicated fractures.

I believe the prognosis also is influenced by the early conservative treatment, and it is my firm belief that many of these are over-rated. You will notice I have not mentioned casts until the treatment of acetabular fractures; it is my opinion that they do not really immobilize and the only good that they do is to permit the patient to be turned over—and even then I have seen patients in casts turned over and they began urinating blood and when turned back it cleared up. Also putting the sling under some especial bilateral fracture has caused me the same embarrassment. So it is advised to do as little for these cases as possible and the complaints will be few.

Even the most deformed pelvis, if not in a female in the child-bearing period, will give an excellent functional result.

In pubic separations there is always the danger of injury to the urethra and bladder. It is hard to imagine, with the severe injury necessary to cause this tearing and separation, that we would not have a contrecoup reaction at the sacro-iliac joint. The x-ray usually confirms this finding with a very small or slight separation.

The best form of treatment for this type of injury is to suspend the patient in a sling. The use of the scultetus binder is advocated. Care must be taken not to compress the pelvis too severely, as one may injure the urethra or bladder.

If the above treatment is not successful, it is advisable to operate, expose the pathology, reduce the separation and secure this reduction with heavy braided silk, Paraham Martin bands or by fusion with bone graft. Care must be taken in open operations involving the pelvis, as it is very susceptible to osteomyelitis. The immobilization of this separation should require 10 to 12 weeks before the patient is allowed to bear weight.

The Treatment of Ununited Fractures of the Long Bones

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NON-UNION or delayed union in fractures is seen with increasing frequency in recent years.* I believe this is probably due to a change in the nature of the fractures and also in their treatment as contrasted with past decades.

The great increase in hazardous industries and automobile accidents has resulted in complicated fractures and an increase in the number of fractures. There are more multiple fractures, in which several bones are involved, more compound fractures, and more severely damaged soft parts which may obviously deter circulation and callus formation. We know that in multiple fractures, deficient callus, with retarded union at one or more points, is quite common as the demand for new bone overtaxes callus output and lowers the quality of osteogenesis. Also, time required for solid bony union is much greater in compound, in lacerated, or contused parts, than in simple fractures.

Our methods have changed with the advent of the x-ray; and in the hands of those of wide experience there has been a decided advance. However, we have often observed that unless there is a proper interpretation of the roentgenogram, better results would be obtained by methods in common use prior to the discovery of the roentgen ray.

Twenty years ago the average practitioner was content to attain what appeared to be anatomical alignment, and pronounced the bones "set." Today the x-ray reveals a disturbing sight to the patient and to the physician, who too often makes several unsuccessful attempts to produce a satisfactory picture from a cosmetic standpoint. By such efforts nature's bone-forming elements are destroyed or materially damaged.

The well known evolutionary process of the healing of a fracture is of the greatest importance and may be described briefly as follows: (1) hemorrhage, (2) formation of blood clot between the fractured surfaces, (3) cellular invasion with the formation of a fine fibrillar network, (4) formation of a hyaline and periosseous substance, and (5) calcification. With the exception of calcification, the process is practically the same as in granulation tissue in the healing of any wound. This process has been compared to the setting of the plaster of Paris in the meshes of a crinoline bandage, the crystallization of the plaster cor-

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* Read before the American Association of Railway Surgeons, September 20, 1937, Chicago.

responding to the precipitation of calcium and the crinoline to the connective tissue matrix.

With this delicate process of repair in mind, the etiology of non-union as practically a local affair is readily understandable. With the exception of the constitutional element involved in multiple fractures, and congenital abnormality of bone structure, non-union is usually the result of the following factors:

1. Severe injury to the soft parts which may sever local blood vessels supplying the area of fracture. This removes one of the essential prerequisites to bone repair. When there is severe injury to the soft parts, granulation tissue will be rapidly formed with the production of scar tissue that will interfere with the normal process of osteogenesis.

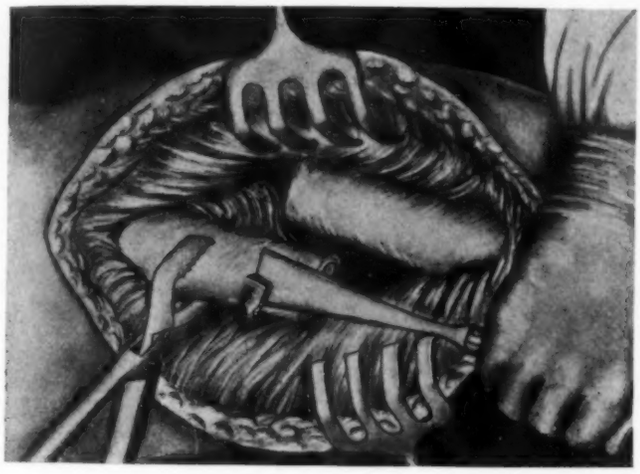


Fig. 1.
"Shavings" are removed from the circumference until there is a continuous flat surface for three or four inches on each fragment

2. Compound fractures are also evidence of more severe injury, but also delay union by interfering with the formation of the local blood clot at the point of fracture which is essential to normal healing.

3. Repeated or excessive forcible attempts to secure reduction, as above described.

4. Operative measures: on a general average, open incision into a fracture delays union, but material impairment must be expected unless care is taken not to strip away the periosteum with soft tissue attachment through which the local blood supply is obtained.

5. Excessive traction by improper use of modern methods of skeletal traction is becoming a more frequent causative agent. High-powered "gadgets" in the hand of the inexperienced are to be deplored.

6. Extensive sclerosis of bone as a result of impaired circulation, which may be demonstrated as condensaton with obliteration of the central canal.

7. Sclerosis as a result of osteomyelitis.

8. Fixation by foreign material, as metal plates, which may repel osteogenesis.

9. Interposition of soft tissue and malposition, which is comparatively rare with modern methods of treatment.

10. Inadequate immobilization.

Methods commonly employed in the treatment of non-union may be enumerated as follows: (1) The denuding of osseous surfaces and approximating with absorbable or non-absorbable suture, as wire; (2) steel plate; (3) plastic step-up or dovetailed wedging of the bone with or without suture and pegs; (4) drilling of the fragments; and (5) various types of inefficient bone grafts, as chip graft, Delageniere graft, pegs, and intramedullary grafts. This is the type of operation most frequently observed in the history of about 50% of ununited fractures, and undoubtedly in many cases is the actual causative agent of continued non-union. Union is induced in some instances despite such measures, but the question is not what nature will occasionally accomplish but by what means osseous fusion can be obtained in the highest percentage of cases. In merely delayed union, fusion can be secured by simple drilling of the fragments, or at times by other methods of local irritation, but in true non-union such methods as above described should not only be discarded but not tolerated, as the percentage of failures is entirely too high.

The inlay method of bone graft is far superior to those above mentioned, but has the disadvantage of removing a considerable portion of the circumference of both fragments from which union is to be secured, and also, in my experience, internal fixation cannot be obtained. A similar method employed by Gill, of Philadelphia, and Sherman, of Pittsburgh, secures excellent fixation with the use of large sliding grafts and steel screws. The disadvantages are the removal of large grafts from the fragments and the employment of foreign bodies.

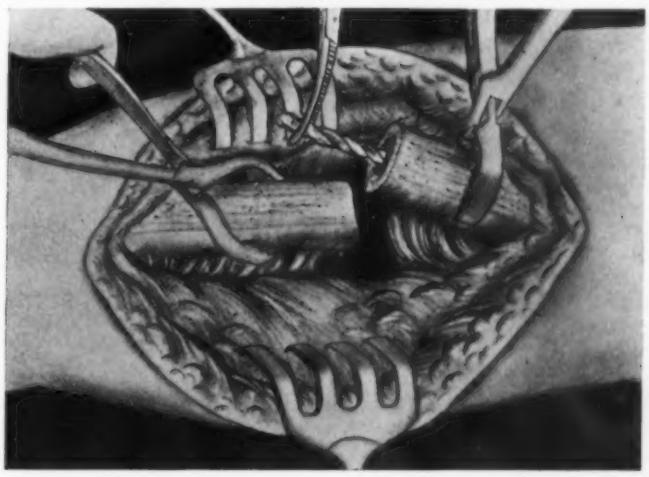


Fig. 2.
Each medulla is reamed out

In 1921, after average success in the treatment of ununited fractures, I came to the conclusion that there might be an improvement in the end results by a method which would permit absolute fixation and at the same time promote osteogenesis. I had previously employed massive intramedul-

lary grafts, inlay and sliding grafts, which are far more efficient than methods above described, but after these procedures motion at the fracture site could always be detected. In consequence, I adopted the following operative technic in ununited fractures of the long bones, which has not been changed since first devised:

An ample incision is made through the skin in order to expose each fragment, when possible, for 4 inches (10 cm.). Routine dissection is made to the site of fracture; all intervening scar and fibrous tissue is removed; the fragments are pared

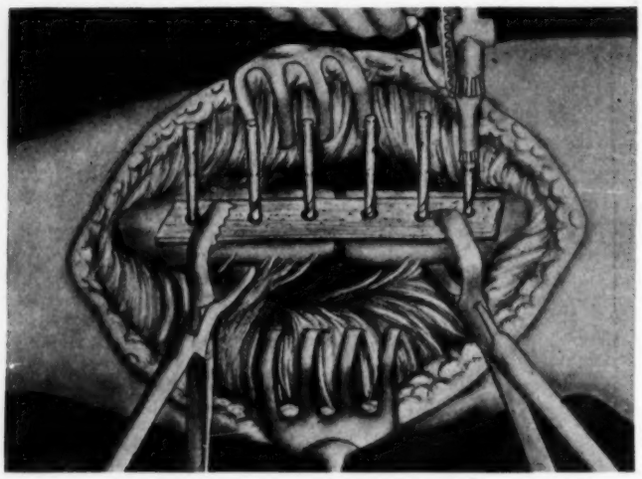


Fig. 3.
Graft consisting of dense bone or cortex with drills in place

with chisel or motor saw, and each medulla is reamed out until normal marrow tissue is reached. The fragments are rotated until the normal relation has been restored. An incision is made through the periosteum of each fragment, for several inches, depending on the length and the anatomic location. The periosteum is stripped from one-half inch to three-fourth inch (1.3 to 1.9 cm.) from the circumference, leaving attached, as much as possible, the soft parts from which circulation is derived. With a chisel, shavings are removed from the circumference until there is a continuous flat surface, for 3 or 4 inches (7.5 to 10 cm.), when possible, on each fragment. A broad flat massive graft is taken from the tibia, which should be of sufficient length, breadth and dimensions to secure firm fixation. With a motor saw, the graft is split longitudinally through the edge or small diameter into two parts, a strong outer plate consisting of dense bone or cortex, and an inner, the endosteum. A strip of endosteum is placed within the medulla, bridging the site of the fracture as reduction is made, normal marrow tissue rich in osteoblasts being thus restored. From the outer plate, or as a a separate graft, a strip of dense bone is taken, from which six or eight autogenous bone nails are made, of appropriate size. This is accomplished by the aid of a rotary file attached to the motor saw and a metal gage to measure dimensions. The strong outer plate is held to the flat surface of the bone, passing across the site of the fracture. Three or four drill holes are made through the graft and each fragment, into which the autogenous bone nails are driven. The remainder of the endosteum is broken into small particles and placed with the "shavings" about the site of fracture.

Spongy bone is always available from the upper extremity of the tibia and can be obtained by a sharp bone curet. About six pieces are removed in this manner and applied around the area of fracture. Spongy bone is more proliferative than any other type of graft, being successful in 100% in an operation which I have devised for a type of paralytic foot. By this method, solid fixation is attained so that when the operation is complete no motion is apparent. The transplantation of endosteum to the medulla and cavernous bone about the fracture is an excellent method to promote osteogenesis. Henderson employs a similar method, which differs from the one described in that he employs beef-bone nails, removes the cortex to the medulla and does not use the transplant of endogenous and spongy bone.

The after-treatment consists in complete fixation by a plaster of Paris cast or efficient splint which remains for a period of eight weeks. When this is removed a convalescent splint is applied, usually in the form of a leather corset to reproduce the cast. Joints are usually incorporated, so that active and passive motion may be carried out as soon as feasible. With rare exceptions, no motion could be detected at the site of fracture after the operation had been completed, and union was apparently firm at the end of eight weeks, but from previous experience with delayed union and ununited fractures protection of some form is required for at least six months after the operation. The reason for this continued protection is explained on a physiologic basis. In the lower extremity, weight-bearing is often gradually per-

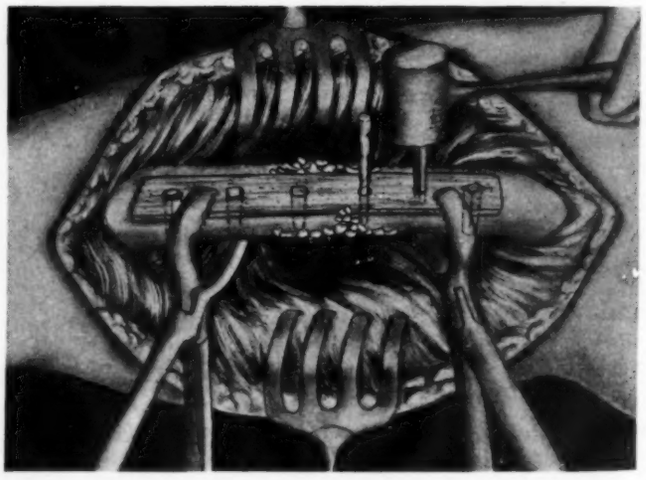


Fig. 4.
Autogenous bone nails of appropriate size inserted into drill holes

mitted by the aid of a Thomas knee brace, and apparatus is not discarded until the roentgenogram demonstrates that the callus is organized.

The bone graft must not be applied under tension, or disintegration will occur with separation or fracture at the point of greatest stress, and undoubtedly this is a factor in many of those cases in which there is a fracture of the graft at the site of

the original fracture. I have repeatedly observed such behavior when a graft has been used for conditions other than ununited fractures; for instance, in bone grafts to the spine, if the transplant is placed under tension to conform to the kyphos or scoliosis, disintegration always occurs with fracture at the point of greatest stress. Also, a graft may be placed in a spine without tension, but after an increase in a destructive process, there may be gradual bending or kyphos with stress on a graft. In such instances there will be disintegration at point of stress, unless there has been sufficient proliferation of the graft itself.

Excessive scar tissue must be excised, and, if there is extensive involvement of the skin with adhesion to the bone, this must be dissected and the wound closed with normal soft tissues of considerable thickness investing the bone. If this cannot be accomplished by plastic arrangement, a pedicle flap or other type of skin grafting should

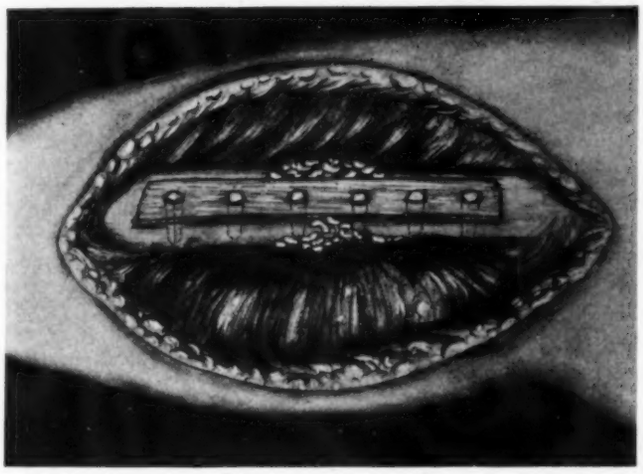


Fig. 5.
Bone graft completed. Note small particles of endosteum placed in and adjacent to the fracture site

be employed, and the operation on the bone deferred until the soft parts have entirely healed. This dense scar tissue about a fracture not only is conducive to sloughing after operation and infection but also prevents revascularization of the transplant and also of the area of the ununited fracture.

Ununited fracture in bone dense and eburnated, as after extensive osteomyelitis, materially lessens the chances of establishing osseous union, and relighting of severe infections is not uncommon. Such cases are more common following pathologic dissolution after improper treatment for osteomyelitis. In infected compound fractures, the fragments are invaded for only a short distance and the onlay graft can be applied to normal bone above and below with less danger of stirring up a latent infection.

There should be no interference in the after-treatment with the evolutionary process of healing, as otherwise there may be impairment of osteogenesis with stimulation of the forces of bone resorption which is a part of the process in bone repair. Bone production and absorption are well balanced in the normal callus. However, if this balance is disturbed from any cause, there may be rapid bone disintegration, and a fracture that is apparently united may separate. This is also true in all fractures, but as healing in ununited fractures is retarded when compared to fresh fractures, a loss of balance can more easily be produced.

The onlay bone graft has been employed in 241 instances with only 16 failures, or 93.3% solid union.

IN CONCLUSION, the advantages of this procedure are maximum fixation and osteogenesis, which can be routinely secured, and no foreign material is employed. From personal experience, I believe that the employment of endosteum and cavernous bone more efficiently promotes osteogenesis than any other type of graft. By the onlay method no bone is removed from the fragments, but a considerable amount of new bone is added and the normal dimensions and strength are finally increased. Should failure or sequestration, with or without infection, occur, the bone is in a much better condition for future treatment than if a large portion of both fragments is excised in the process of operation.

Due consideration must be given to the physiologic principles of bone regeneration at the time of operation and in the cultivation of osteogenesis by efficient after treatment, until repair and functional restoration of the entire member is complete.

Discussion:

DR. CHESTER C. GUY, Chicago: In opening the discussion of this paper my remarks will be brief. In Dr. Campbell's discussion of the etiology and pathology of non-union, he brought out one point which I believe is of particular significance and which is too often overlooked, and that is that in the union of fracture of the long bones the mechanism is a local process. In order to have satisfactory union we must have reasonable apposition and immobilization and a reasonable amount of circulation in the region of the fracture. I think too often when we are getting a non-union, we forget the effect of circulation in the leg, and we feed our patients various things that are supposed to produce callus formation when what they need is stimulation of circulation of the part rather than leaving it inert in a cast for an indefinite period of time.

Anyone who has watched Dr. Campbell's pictures, who has studied Dr. Campbell's technic and who has done any bone surgery himself, can appreciate that his statistics showing 94% of his cases have had bony union are an excellent testimonial to Dr. Campbell's surgical ability. The surgeon has to be a pretty good carpenter to get apposition in many cases in applying the simplest form of a fixation device, but to carry out an operation such as Dr. Campbell has described, with the manufacture of nails and the application of a massive graft, and to do this so that there is excellent and firm immovable apposition, is a real piece of surgery. You have not only to be a carpenter; you have also to be a cabinet maker.

DR. EDWIN W. RYERSON, Chicago: The subject of non-union of a fracture is one of great interest to orthopedic surgeons, and for a good many years I have seen more cases of ununited than of fresh fractures, but that is to be expected in a large general hospital where the general surgical department examines almost all the fresh fractures. As Dr. Campbell said, there is no one individual reason why some fractures do not unite. We know that in some long bones there are certain places where non-union ordinarily occurs: the lower third of the tibia, the middle of the humerus, the shaft of the femur and the neck of the femur, which is still the "unsolved

fracture". The constitutional factors are very promptly dismissed with as few words as Dr. Campbell said, because the constitutional causes are the rarest causes of non-union, except in children. Watson Jones believes that non-union is caused more often by insufficient immobilization than by any other cause, and I am inclined to believe this is true.

Fractures of the humerus are very difficult to hold firmly by any kind of apparatus, and fractures of the middle of the humerus are the ones I have seen most often in the state of non-union. A young man may have his fractured humerus placed in perfect position and well immobilized, and at the end of three to five months you may find that no union has taken place. So we must endeavor to get accurate immobilization, and if that fails, as it will fail in some cases because the individual cannot make new bone, then we must resort to operative interference, but all fractures that can be held properly and healed without open operation should be so treated. I am not in favor of doing open operations on simple fresh fractures. I think the general tendency is to operate too many fractures and the distress that has followed in the wake of this wave of enthusiasm we have all seen.

I am not in favor of metal plates when it is possible to avoid using them. Many of you have seen Sherman's work. His technic is admirable and his results are satisfactory and we know this is due to the teamwork and the asepsis he has mastered, but in most men's hands disaster is apt to happen more often using this technic than using ordinary interference.

One point to be brought out is that, in doing an open operation, do not scrape away the periosteum; do not try to get a beautiful exposure. I have seen many a good surgeon make a beautiful exposure, and strip everything away from the bone in order to get a good exposure. This I consider bad surgery.

When one is confronted with an ununited fracture, there is only one thing to do and that is to introduce an autogenous bone splint by some approved technic. After the lapse of a good many years I have come to the conclusion that the onlay graft method of Campbell or Henderson is the best method. There is no objection to an intramedullary graft, although both Henderson and Campbell look on it with some suspicion, but I have had a lot of old fractures that made good union after such a splint was applied. But this is not the most physiological method.

So do not, when you have an ununited fracture of the long bones, cut down and free up the ends from the periosteum and put in wires and nails and screws if you can avoid it. Use a bone graft. If there is non-union, make up your mind that autogenous bone splints will be necessary to get union. Then how you hold it is of secondary importance, whether you use beef-bone screws or whatever method you prefer, but use some form of autogenous graft of as large size as you can get. Remember that the value of many patients is in proportion to the size of their tibias; put in a good big graft and fasten it by good means and if nature is kind the patient will get a union.

DR. ARTHUR CONLEY, Chicago: I would like to take this opportunity to compliment Dr. Campbell on his excellent results. I have had some grief with these cases. I was particularly impressed with congenital defects in the tibia because I had such a case upon which I operated about nine times and did not get a union. I think one of the most important features in these cases is asepsis and another one is the accuracy of reposition of the fragments. Of course, removal of the scar tissue is important, but whether maintenance of apposition is gained by intramedullary graft or onlay or inlay grafts depends upon the individual's mechanical ability. I agree that the onlay graft is the most difficult to apply.

The theories underlying ununited fractures are varying. For three years I took calcium and phosphorus readings on every patient who entered the fracture service at Cook County Hospital, hoping that we would find someone who would develop non-union which we could attribute to disturbance in calcium-phosphorus ratio. These determinations were done under the very best circumstances, and we also ran Wassermann tests. On every patient who entered that service, whether with fractured ribs or femurs or tibiae, multiple blood calciums were run at intervals, particularly when we started to find a delayed union. In all the patients who entered the service during this three-year period I do not recall having one single case that we might have attributed to faulty calcium-phosphorus ratio. There was one doubtful case but we could prove nothing.

I think the largest cause of non-union is meddlesome therapy. I think with improvements in x-ray technic and with fewer attempts at manual reduction in certain cases there will be fewer non-unions.

DR. S. PERRY ROGERS, Chicago: It would be impossible for me to attempt to add or detract from these discussions or from Dr. Campbell's excellent paper. My own limited experience has turned up three cases of non-union involving the femur and two of them have been of the supracondylar type that are supposed to unite in spite of anything. The first was due to bad treatment in the form of over-extension over a period of weeks, producing a gap of two inches or more; this was finally healed by conservative methods. The second case was due to an impossible amount of interposition because of the long fragment of shaft coming down anteriorally to the level of the patella and forming a sort of purse-string of the anterior periosteum and tendon. After proper apposition this threw more callus in three weeks than I have ever seen in anybody. The real headache was a subcapital fracture of the neck, misused for six months, in which there was interposition of the posterior capsule; the final result is bad.

There is one question I would like to ask and that is the role of syphilis. It happens that I have had the opportunity of doing considerable bone work for three years in one of our tropical colonies where the incidence of syphilis is 50% and the incidence of malaria and hookworm and anemia is even higher. If our surgical patients had a hemoglobin of about 25% they were in good shape. Also the general standard of immediate care of fractures was low. We saw union of fractures in the most bizarre positions and plenty of excess callus and non-unions. Related to that is our recent experience of the condition opposite to non-union or synostosis, which is just as troublesome as non-union. Of course, I am not quite ready to recommend inoculation with syphilis as a cure for non-union, but I can remember a few years back when syphilis was the first thing inquired about in any ununited fracture, whereas my feeling is that the relationship is just the opposite.

DR. JOHN G. FROST, Chicago: I have not had such an amount of experience with ununited fractures as our essayist, Dr. Willis C. Campbell, has had, but Dr. Campbell has brought to our attention that this pathological condition is local. Dr. Conley has also brought to our attention that he considered there was no change in the calcium content of the bone obtained by the administration of calcium.

My experience during the last eight years has been that by the administration of a calcium-phosphorus preparation known as Alphaden, given in tablet or capsule form, with syrup of ferric iodide, 15 drops per dose given three times a day, there has been a pronounced tendency in the deposition of calcium at the point of the ununited fracture. I have not made blood determinations to ascertain the amount of calcium in the blood after the administration of Alphaden but it has been my experience that patients taking this internal medication improve in their general health and there is a shortening of their convalescence. I have a boy in my ward at the County Hospital who has a very extensive osteomyelitis of the left femur. He has taken this preparation and has gained 30 pounds in the last four weeks. Dr. Campbell told me he is now trying this same preparation but to date he has not had the results that I have obtained.

DR. WILLIS C. CAMPBELL, Memphis, Tennessee (closing): I want to express my appreciation for the discussion and for the emphasis of the many features concerned in this condition.

Dr. Ryerson states: "We have had a difficult problem in immobilizing the humerus," and I am certain that immobilization is a very prominent cause of ununited fractures. I think many of these ununited fractures are due to some of the gadgets we are using at the present time, not that they do not have their place but they have a place only when properly applied. As to the intramedullary grafts, I have no doubt that in many instances good results have been obtained, but the question is not what is going to give a good result, but rather what method is most successful in the highest percentage of cases.

I entirely agree with Dr. Conley as to the question of calcium-phosphorus balance. I have tried this in 25 cases and have never found imbalance in any of these and do not routinely employ this test because I think it is absolutely useless and a waste of time. I think most of us have come to the conclusion that it is not a causative agent in ununited fractures.

Dr. Rogers mentioned a non-union which is very rare and in which it is very difficult to acquire union and that is the supracondylar fracture of the femur where union practically always occurs. I have one case in which I have employed, not the onlay graft because the fracture was too short, but the autogenous bone nails, to fix the fragments together. This case has been a failure. I have another case of the same type where the knee joint was ankylosed, in which we employed the onlay graft. This was a radical procedure but it is much better to secure a union with a stiff knee than to have no union at all. This case was successful. The other patient has recently returned and we hope to do an onlay graft; we plan to put the graft across the knee and do a fusion of the knee at the same time.

I agree with Dr. Rogers as to the role of syphilis. I have seen two cases in which syphilis apparently impaired osteogenesis. In syphilis there may occur an exuberant formation of callus of poor quality. I think this is a factor but it is a very rare one and it should not be considered of prime importance by any means. There are many instances in which the Wassermann is positive in ununited fractures but has no relation as a causative agent.

As to the calcium preparation, Alphaden, which is employed with ferric iodide, I have used it recently but not for a sufficient length of time to state the end results. So far I have seen no effect. However, I intend to pursue this treatment in ununited fractures and in other cases where there is deficient calcium in the hope that I will get as satisfactory results as Dr. Frost has demonstrated.

In conclusion, I agree with Dr. Guy that we must be carpenters and cabinet makers, but we must also consider the physiological factors of bone regeneration, and in addition to being carpenters and cabinet makers we must be gardeners as well and consider the soil with which we have to deal.

Mid-Winter Industrial Clinic

THE CENTRAL STATES SOCIETY OF INDUSTRIAL MEDICINE AND SURGERY held its annual mid-winter clinic at Cook County Hospital, Chicago, on Friday, December 3, 1937.

The program was as follows:

"Diagnosis of Shoulder Joint Lesions"—FELIX M. JANSEY, M.D., Chicago.

"Reduction of Fractures of the Spine"—CHARLES N. PEASE, M.D., Chicago.

"Show Cases"—ARTHUR H. CONLEY, M.D., Chicago.

"Medical Problems in Industry" — LEROY H. SLOAN, M.D., Chicago.

"Statistics: Data of 12,500 Examinations"—ALFRED RASMUSSEN, M.D., Chicago.

"Burns—Treatment and Prognosis"—URBAN E. GEBHARD, M.D., Milwaukee.

"Improved Application of Bone Plates"—WILL F. LYON, M.D., Chicago.

"Occupation Dermatitis" — B. BARKER BEESON, M.D., Chicago.

"Personal Equation in Accident Causation"—HART E. FISHER, M.D., Chicago.

"Bone Tumors in Relation to Trauma"—CARLO S. SCUDERI, M.D., Chicago.

"Findings in Undulant Fever in Cattle and Hogs"— E. J. KIRK, M.D., Omaha.

"Vertebral Injuries"—E. C. EMERSON, M.D., St. Paul.

"Fractures"—JAMES J. CALLAHAN, M.D., Chicago.

"Examination of Low-Back Industrial Injuries"—GEORGE L. APFELBACH, M.D., Chicago.

"Compound Fractures"—ROBERT L. KERRIGAN, M.D., Michigan City.

"Hip Joint Injuries" — WILLIAM R. CUBBINS, M.D., Chicago.

After dinner, at the Palmer House, at 7:00, the Scientific Program included:

"Diagnosis of Peripheral Nerve Injuries," by THEODORE T. STONE, M.D., Chicago, and

"The Treatment of Peripheral Nerve Injuries," by ADRIEN VERBRUGGHEN, M.D., Chicago.

DR. JAMES J. CALLAHAN was Chairman at the meetings, and DR. FREDERICK W. SLOBE, President of the Society, presided at the dinner.

The attendance was larger than at any previous mid-winter meeting of the organization; more than 300 witnessing all or part of the clinical demonstrations. And, for the first time in the history of these meetings, a majority of the visiting doctors were from the central states other than Illinois. Iowa and Indiana were particularly well represented, and there were members from Missouri, Minnesota, Michigan, Wisconsin and Ohio.

Cost of Eye Injuries

AMERICAN industry is paying $50,000,000 annually for eye accidents, was the estimate made by Charles O. Cozzens, vice-president American Optical Co.* Fully one-half this cost could be eliminated within a year, he said, if ordinary safety methods were employed. U. S. industry loses or repairs some 200,000 eyes per year. Actual cost of the average industrial eye accident is estimated at $250, while the cost imposed on industry when an eye is lost is $2,000. Types of industries leading in eye accidents, in order of importance, he says, are: Metal working and refining, wood industries, process industries, construction, food industries, coal mining, mining (other), and utilities. On the constructive side Mr. Cozzens reported some encouraging data. A metal-working plant spent an average of $1,668 per year on eye accidents during a 5-year period when goggles were required on only obviously hazardous jobs; following compulsory wearing of goggles on all jobs, yearly costs were reduced to $88. A steel company prevented destruction of some 6,000 eyes over a 10-year period at a saving of $12,000,000 in compensation alone.

* *American Mutual Magazine*, accredited to *Safety Engineering*.

Toxicity of Organic Silicon Compounds

— 1. *Tetraethyl-ortho-silicate* —

JOSEPH A. KASPER,
CAREY P. MCCORD,
and
WILLIAM G. FREDRICK,
Detroit, Michigan

ORGANIC compounds containing silicon are finding industrial application and, at the present time, chiefly as solvents, paint components, and stone preservatives.* The known injurious properties associated with silica (SiO_2) and asbestos (a complex magnesium silicate) are specifically associated with these respective compounds and not solely with the silicon component. It is established that elemental silicon will not produce the proliferative action which is so characteristic of silica and less characteristic of asbestos. On this account, it is not predictable that organic compounds of silicon will prove to be toxic because of the mere presence of that metalloid in the chemical structure. In the absence of known extensive information relative to the toxicity of organic silicon compounds, their increasing industrial use requires appropriate studies of their physiologic actions.

The chemical properties of silicon are such as to locate it as the second member of Group IV of the periodic system, which leads to close similarity to carbon, the first member of this group. For this reason, silicon may replace carbon in many organic and metallo-organic compounds. Silicon forms a well defined series of silanes analogous to the methane series of hydrocarbons—for example SiH_4, Si_2H_6, etc. Silicon may form complex hydrocarbons termed silicanes, such as tetramethyl silicane, $Si(CH_3)_4$, and tetraphenyl silicane, $Si(C_6H_5)_4$; also silicides such as magnesium silicide, Mg_2Si, analogous to carbides; acids, such as silico-oxalic acid, $Si_2O_2(OH)_2$, esters and many other aliphatic, aromatic, cyclic and heterocyclic compounds.[1]

Tetraethyl-ortho-silicate, $Si(OC_2H_5)_4$, is a limpid water white liquid, boiling at 165.5°C. Its density is 0.933 20/20 and its vapor pressure is relatively low. Air saturated with ethyl silicate vapor at room temperatures (25°C) will contain approximately 17 milligrams per liter of the vapor. The liquid has a characteristic odor, unobjectionable to most persons. In common with most esters, ethyl silicate is only sparingly soluble in water or aqueous solutions, but itself is an excellent solvent for fats, oils and similar high molecular weight organic compounds. It is miscible with alcohols, esters, and ethers.

Ethyl silicate is used as a vehicle and solvent in paints and lacquers, as a stone preservative, in heat resistant coatings, as a cement or bonding agent for refractories and other materials and as a strengthening or hardening agent in sand molds, brick, textile products and the like. Small quantities of ethyl silicate are used in dentistry for the sealing of dental surfaces.

Work Materials and Procedures

THE ethyl silicate used in these experiments was purchased from the Carbide and Carbon Chemicals Corporation. The material subsequently was carefully fractionated, only that portion boiling within 0.5° of 165.5°C being reserved for use. That the commercial product is relatively pure is indicated by its narrow boiling range.

Other substances used for control purposes include silicic acid, ethyl acetate, ethyl alcohol, methyl silicate, corn and olive oil, etc. Concurrently other series of animal experiments contributed control data following the administration of a large variety of dusty materials, including various types and particle sizes of silica, silicates, the compounds of iron, calcium, titanium, sodium, manganese, carbon, etc.

In these investigations, 828 small animals (rabbits, white rats, guinea pigs) were utilized. Of this number, 228 were used in the experiments directly related to ethyl silicate and immediate control work. A few humans were subjected to the action of ethyl silicate through skin application and patch tests for the purpose of determining the possible irritant properties of this substance.

The animals, in varying numbers and at various times, were subjected to the action of different quantities of ethyl silicate or immediate control materials introduced intraperitoneally, intravenously, subcutaneously, intra-tracheally, orally and through inhalation. At times the ethyl silicate was dissolved in corn or olive oil. At other times minute quantities of the ethyl silicate itself were administered. While ethyl silicate possesses no marked local irritant properties leading to inflammatory reaction, certain of the direct control materials such as ethyl acetate and ethyl alcohol are directly irritating. This fact has been duly weighed in connection with results.

A distinct difference was noted in the response of young and old animals to the action of ethyl silicate, young animals being much more susceptible. A possible explanation of the anomalous difference apparently may be found in the fact that animals having reached maturity possess more adipose tissue, particularly within the ab-

1. Just what constitutes an organic chemical compound is a matter of definition and agreement. Some such compounds of carbon as silicon carbide are in some publications listed as inorganic and in others organic. The substitution of silicon for carbon in these borderline compounds may give rise to objection that such do not properly constitute organic substances. In the present publication such a compound as silicon carbide is arbitrarily accepted as inorganic. Since this series of investigations deals foremostly with complex silicon compounds, manifestly organic in nature, it becomes unnecessary for the time being to attempt any sharp marking of the boundary line between organic and inorganic substances in which silicon is a component.

* From the Bureau of Industrial Hygiene and the Bureau of Laboratories, Department of Health, Detroit, Michigan.

dominal cavity. Ethyl silicate is a powerful solvent for fats and conversely is readily absorbed by them. It is believed that these fatty tissues rapidly absorb large portions of ethyl silicate particularly when introduced intraperitoneally and under such circumstances the action of ethyl silicate is minimized.

The criteria through which the action of ethyl silicate has been appraised embrace the following: behavior responses (clinical observations), autopsies, microscopic tissue examinations, blood counts, and determinations of minimal lethal doses.

Basic Injurious Action of Ethyl Silicate

REGARDLESS of the method of administration, but with regard for dosage and time element, the administration of ethyl silicate invariably leads to a characteristic response to which most other manifestations apparently are related. This basic injury is at the location of pulmonary capillaries which are ruptured. These ruptures in turn lead to marked hemorrhage into the air sacs, with some rupturing of alveolar tissues. This change may appear well within 10 minutes following intraperitoneal introduction of minute quantities of ethyl silicate and without occurrence of the demonstrable local injury within the abdominal cavity. To a limited extent, the capillaries of the heart and heart muscle are likewise injured by ethyl silicate. If death be not immediate, hemolysis may take place leading to hematuria and anomalies in blood counts. Also, in those animals surviving for a few days, an acute nephritis regularly may be demonstrated. Further sections of this report extend, without exhausting the materials in hand, this concept as to the foremost actions of ethyl silicate.

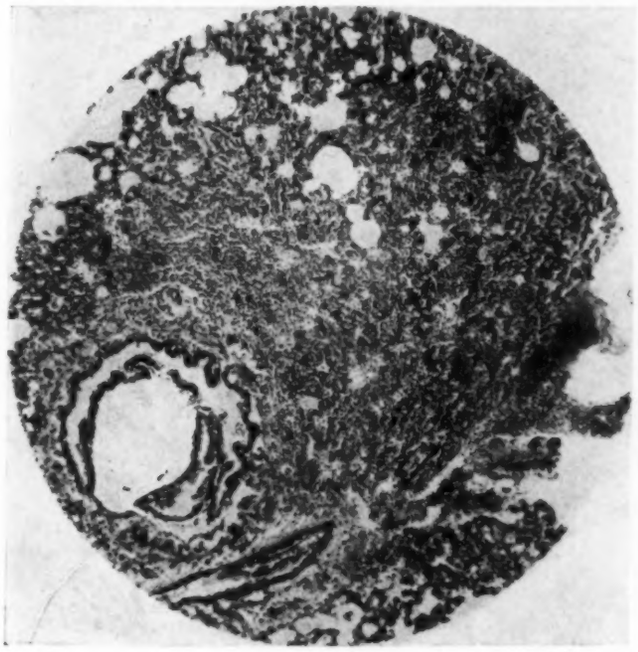


Fig. 1.
Section of lung from rat intraperitoneally injected with ethyl silicate (0.06 ml. per 100 gm. body weight) three days previous to spontaneous death.

Gross and Microscopic Tissue Manifestations

THE following description of the gross and microscopic findings is based upon a study of the tissue changes that developed in rabbits and rats. The pathological changes observed in rabbits were the result of intravenous administration of ethyl silicate and sodium silicate in doses ranging from 0.023 ml. to 0.036 ml. per 100 gm. of body weight. These compounds, as well as methyl silicate and silicic acid were administered to rats by the intraperitoneal method in doses that were comparable with those administered to the rabbits.

Examination of rabbits that died within a very short time after the intravenous injection of ethyl silicate revealed a striking pathological result. Invariably, the heart was found to be greatly dilated and the myocardium presented an unusually pale appearance and was of soft consistence. This pallor of the heart muscle and the loss of its tonicity strongly suggested myocardial necrosis, but this impression was not supported by microscopic findings. The microscopic changes that were observed were relatively insignificant and consisted only of a slight edematous change in muscle, particularly that portion bordering the ventricular cavity. No change was found in the endocardium.

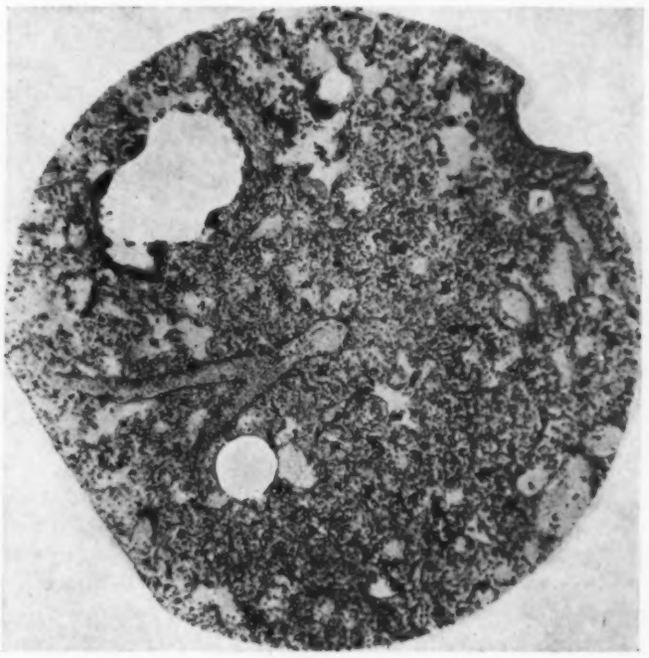


Fig. 2.
Section of lung from rabbit intravenously injected with ethyl silicate (approximately 0.04 ml. per 100 gm. body weight) five minutes previous to spontaneous death

The lungs, on the other hand, showed a pathological condition that was a strikingly characteristic manifestation of ethyl silicate effect. Multiple hemorrhages were found in both lungs. Those observed in the upper lobes were relatively small and discrete, but in the lower lobes the parenchymal hemorrhages were massive and resembled changes that usually occur in the early stage of

lobar pneumonia. On section, however, no gross evidence of an inflammatory reaction could be found, but free blood was traceable into the bronchi and trachea. Occasionally, an animal would show signs of hemoptysis.

Representative sections of the affected portions of the lungs were studied microscopically. These studies revealed an intense engorgement of the alveolar capillaries and small arteries in the involved portions of the parenchyma, and a surprising freedom of any reaction in the intervening portions of the lung tissue. Associated with the engorgement of the blood vessels, wherever this change was observed, was interstitial edema and much free blood filling the alveolar spaces. Rupture of the capillary walls accounted for the presence of the blood in the alveoli. Swollen endothelium was noted in some portions of the capillary system to suggest that there was a response to a highly toxic substance. A study of the other parenchymatous organs uncovered nothing unusual at this early stage of the reaction to ethyl silicate administration.

The gross appearance of the brain of the rabbits in this series of examinations was not unusual. However, in all brains examined microscopically, peculiar deviations from the normal were found in the cerebral capillaries in the deeper portions of the brain. Regularly these were observed to contain bubbles or globules interspersed between collections of red blood cells. The inclination is to believe that these bubbles represent air emboli from air aspirated through damaged air sacs arising from the immediate action of ethyl silicate. It is, however, conceived that these apparent vacuoles may represent globules of the ethyl silicate itself. Fig. 3 is a photomicrograph showing large numbers of these vacuoles or globules in one cerebral capillary.

The tissue changes produced by ethyl silicate after intraperitoneal injection were essentially the same as when this compound was introduced intravenously in the experiments with rabbits. These manifestations were identical in all respects with those observed in the rabbits provided the dosage was sufficiently great to cause death quickly. On the other hand, whenever the rats survived following the administration of sublethal doses, the gross and microscopic findings were somewhat different.

Usually, when the rats continued to live for three or four days after the intraperitoneal introduction of ethyl silicate, the hemorrhagic changes in the lungs were complicated by the development of a pulmonary edema, and in some instances lobular pneumonia made its appearance. Phagocytic activity of the monocytes became apparent and many of these cells were found to be filled with granules of blood pigment. At this time microscopic changes were noted in the myocardial fibers, consisting of cloudy swelling.

Kidney changes also began to appear after four days following the intraperitoneal injections of ethyl silicate. The gross changes consisted of softening of the whole organ and a pale grayish-brown discoloration. Microscopic examination of such organs invariably revealed extensive albuminous degeneration and cloudy swelling of the epithelium of the convoluted tubules. In a few

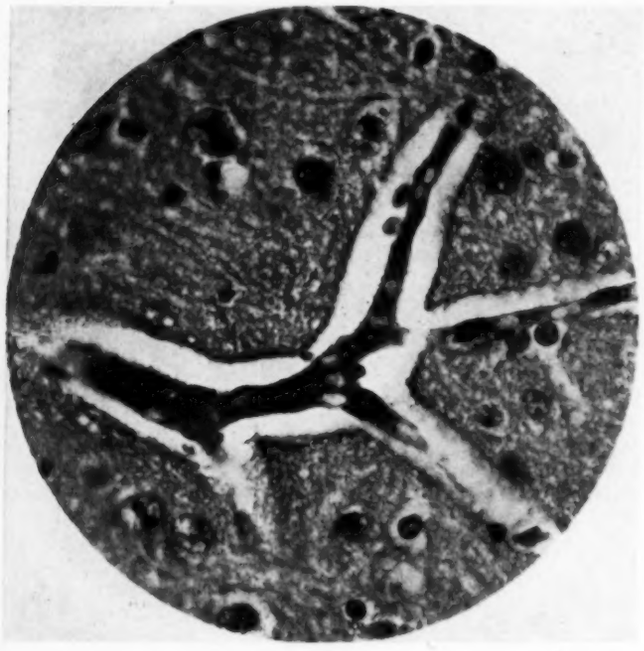


Fig. 3.
High-power magnification of small vessel (arterial) of the cerebrum of a rabbit intravenously injected with ethyl silicate five minutes before spontaneous death. The lumen of this vessel contains many vacuoles closely resembling air or gas bubbles trapped between blood cells but these apparent vacuoles may represent globules of ethyl silicate

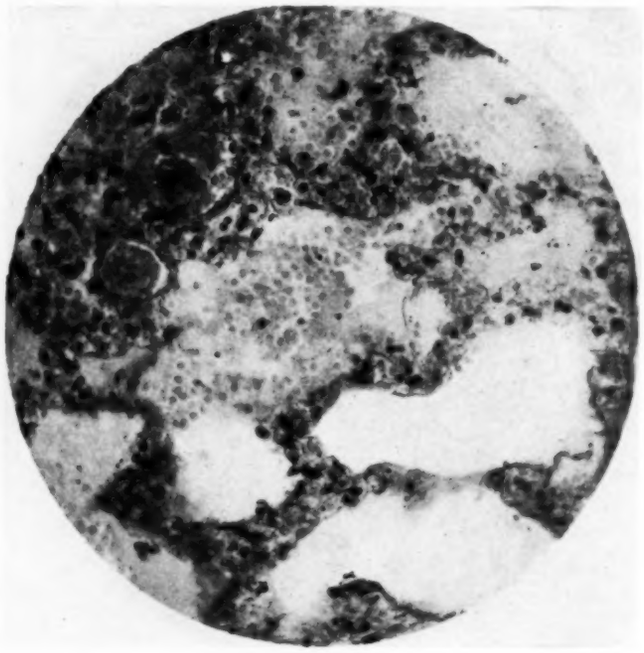


Fig. 4.
High-power magnification of section of lung from rabbit injected intravenously with ethyl silicate. The parenchyma was flooded with extravasated red blood cells due to ruptures of alveolar capillaries. The broken ends of such vessels are clearly demonstrated in this field. This reaction occurred five minutes after the injection of the ethyl silicate

instances, glomeruli contained extravasations of red blood cells within their capsules.

In the spleen, the only changes noted were those associated with congestion and increased depositions of blood pigment granules in the pulp. The mild, local action of ethyl silicate, when introduced intraperitoneally and in animals surviving for a few days or longer, was associated with yellowish discoloration of the surface of the liver where fat-like masses were encountered on the capsule. The microscopic findings under such conditions were those of a necrotic change taking place in the capsule of the liver and the superficial liver cord cells. A few rats showed effects of peritoneal irritation by ethyl silicate. Grossly, the peritoneum presented a translucent instead of the usual transparent appearance. This change was found to be due to a swelling of the endothelium and accumulations of monocytes at the site of the localized irritation.

While sodium silicate, when introduced by the intraperitoneal method, produced the major changes observed to be caused by similarly introduced ethyl silicate, it led to more rapid necrosis of the cells with which it came in direct contact. The necrosis of the liver cells was observed to be quite marked and extended deeper into the liver lobes than when ethyl silicate caused a similar degeneration. The changes in the kidneys also appeared to be more advanced.

Silicic acid was also administered intraperitoneally. The action of this substance was confined to the site of inoculation and small foci where it was deposited, chiefly in the omentum and on the surface of the peritoneum. The characteristic change produced in the tissues affected by silicic acid consisted of a development of very small round white nodules. Upon microscopic examination, these were found to be composed of aggregations of monocytes which appeared to proliferate locally at the site of irritation. Distributed among the monocytes were collections of a moderately translucent substance that resembled a colloidal compound. Neutrophilic polymorphonuclear leucocytes were also present. A foreign-body reaction was exhibited by monocytes which arranged themselves in rows about the colloid-like particles. Occasional crystal-like particles could be seen in some of the nodules. Such particles were of irregular shape and possessed jagged edges. They did not seem to evoke the same phagocytic response on the part of the monocytes as did the pink substance that appeared to be less solid.

Ethyl silicate administered to rats by inhalation in lethal dosage caused death within four days. The gross changes observed in the lungs were substantially those caused by the intravenous injections in rabbits and the greater doses administered intraperitoneally to rats, namely, multiple pulmonary hemorrhages. In addition, the kidneys were more markedly affected than was the case when this same compound was introduced by the intraperitoneal method.

The microscopic studies of the kidneys after inhalation of ethyl silicate revealed very extensive necroses of the tubular epithelium. These changes resembled those produced by large doses of mercury, and were accompanied by large deposits of a blue staining substance resembling calcium, particularly in the collecting tubules. The glomeruli were also affected under the conditions of this experiment.

Minimal Lethal Doses

FIFTY-SEVEN young, male, white rats, ranging in weight from 113 to 250 grams were injected intraperitoneally with quantities of ethyl silicate from 0.06 ml. to 1.14 ml. per 100 grams of body weight. For 21 of these animals, ethyl silicate per se was introduced. In the reaminder, the ethyl silicate was dissolved in either olive or corn oil. The latter were controlled by the injection of 1 ml. of these oils with negligible results. Still other control animals were left untouched. All animals receiving quantities of ethyl silicate in excess of 0.56 ml. died within approximately 60 minutes. In the range from 0.06 ml. to 0.56 ml. the animals died, with one exception, within three days. No differences were noted in the two groups respectively subjected to ethyl silicate direct and ethyl silicate in vegetable oils.

Nine young male rats receiving from 0.02 ml. to 0.04 ml. of ethyl silicate per 100 grams of body weight survived and presented normal weight increases for the duration of the experiment, representing several weeks. In another series of 25 animals (rats) subjected to the action of ethyl silicate in doses ranging from 0.06 ml. to 0.25 ml. of ethyl silicate per 100 grams of body weight all died within four days.

Subcutaneous injections were made in a series of nine young male rats of quantities of ethyl silicate ranging from 0.09 ml. to 0.35 ml. per 100 grams of body weight. Of these animals, five survived longer than four days indicating that the lethal subcutaneous dosage is higher than for intraperitoneal doses. Results are similar to those exhibited by the intraperitoneal series.

Ten rabbits were injected intravenously with undiluted ethyl silicate. The minimal lethal dose under such circumstances is near 0.02 ml. per 100 grams of body weight. Death took place in some instances within five minutes.

Uncompleted work suggests that ethyl silicate vapors in concentrations from nine to 20 mg. per liter of air is fatal for rats within five days when breathed for a total period of only four consecutive hours. Rats exposed to a concentration of 1.4 mg. per liter of air eight hours per day for 17 days survived, but did not obtain weight increases equal to their controls.

Changes in Blood Pictures

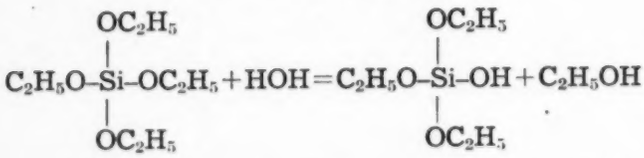
IN A SMALL series of rats injected intraperitoneally with ethyl silicate or silicic acid (0.08 ml. per 100 grams of body weight), such minimal quantities as would lead with expectancy to survival of at least four days, repeated

complete blood counts were made. From this limited work, it appears that within 48 hours a diminution of approximately 20% erythrocytes takes place without any corresponding diminution of hemoglobin. The color index remains high. This fact is probably to be associated with the presence of extracellular hemoglobin resulting from hemolysis. The change is greater in the case of silicic acid than with ethyl silicate. In the case of white cells, a diminution of approximately 25% appears in the ethyl silicate animals within 48 hours, but for the silicic acid series an increase of 50% was noted. With respect to differential counts, both chemicals produced within 24 hours sharp increases in neutrophilic cells at the expense of both the large and small lymphocytes. This change appears to be transitory.

Immediately following the injection of either ethyl silicate or silicic acid, there may be detected a sharp rise in neutrophils, and a corresponding diminution in lymphocytes. The extent of observations made with respect to blood changes, warrants no fixed conclusions.

Comment

ETHYL silicate is a true ester analogous to ethyl acetate, which, in the presence of acids or bases, readily undergoes hydrolysis, with the formation of ethyl alcohol and hydroxy-esters, as shown in the following equation:



As hydrolysis progresses, more and more ethyl groups are lost until the end products of the reaction are H_4SiO_4 or $H_2SiO_3H_2O$ (hydrated silicic acid) and ethyl alcohol. The question then arises as to whether the action is due to the ester itself, the intermediate hydroxy esters, silicic acid, ethyl alcohol or the silicate radical. In an attempt to answer this question, injections of ethyl acetate, sodium silicate, ethyl alcohol and silicic acid were made intraperitoneally. Appropriate observation and examination of the animals so treated revealed that only silicic acid and sodium silicate gave rise to similar reactions. However, the reactions were not identical to those obtained from ethyl silicate and provided variations in local responses, blood changes, time and severity of injuries. While the dosage of silicic acid required to produce death is somewhat higher than that possibly provided by hydrolysis of ethyl silicate, it may be reasonably presumed that the latter is more available for rapid action.

In industry, the outstanding concern in the toxic properties of silicon compounds is in silica, which under conditions of adequate exposure has produced large numbers of instances of characteristic silicosis. Notwithstanding, in a large body of information relative to silicosis, there exists no adequate understanding of the precise medium through which silica in contact with living tissue brings about the changes characteristic of silicosis. Much speculation and investigation have been directed to the concept that silica, taken into the body, undergoes chemical changes allowing a series of dissimilar silicon chemical entities, some one or more of which is responsible for the causation of silicosis. In the absence of any definite findings from this type of inquiry, based on the foregoing assumption, it may prove advantageous to approach this problem from precisely the opposite point of view.

It is conceived that possibly more nearly exact information may be obtained from the study of silicon compounds (such as ethyl silicate) which, as such or through their subsequent chemical change, may lead to quick action upon living tissue with acute responses in some manner related to the slowly produced lesions characteristic of silicosis.

Summary

ETHYL silicate (tetraethyl-ortho-silicate), an organic compound of silicon, industrially used as a stone preservative and solvent, has been found, from animal experiments, to possess highly injurious properties.

In these experiments, 228 small animals (rabbits, guinea pigs and rats) were subjected to the action of ethyl silicate and suitable control substances in different amounts and at various intervals administered intravenously, intraperitoneally, subcutaneously, intratracheally, orally, and to a limited extent through inhalation.

The minimal lethal dose, when introduced intravenously into rabbits, is approximately 0.2 ml. per kilo of body weight; death usually takes place within one hour. The minimal lethal dose for rats, when administered intraperitoneally, is approximately 0.06 ml. per 100 grams of body weight; with rare exception, death takes place within four days.

Regardless of the method of introduction, the chief initial action of ethyl silicate is centered in the pulmonary tract. Rupture of terminal capillaries is accompanied by pulmonary hemorrhage, which occurrence stands in relation to certain other pathologic changes, such as anemia, hematuria, secondary pneumonia, etc. Pulmonary hemorrhage associated with ruptured capillaries may be demonstrated within 10 minutes after appropriate intraperitoneal injection and in the absence of other than trivial inflammatory reaction within the peritoneal cavity.

In animals surviving the effects of the primary action of ethyl silicate, a definite acute nephritis may be demonstrated.

Although ethyl silicate possesses no proved physiologic properties of a type characteristic of the slow action of silica in producing silicosis, this organic substance, through animal experiments, displays a high degree of toxicity, acute in nature, and possibly related to the slow action of silica.

Fatigue

—*In Its Relation to Accident Prevention*—

J. R. GARNER, M.D.,

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ACCIDENTS do not happen — they are caused.*

Occasionally the causative factor in the production of accidents is attributable to some element entirely beyond human control, a mechanical failure, but more frequently the crime—and crime it morally is—is directly or indirectly chargeable to man failure.

E. S. Bogardus has reported a survey of 2,678 accidents among which only 17.2% were found to be due to some form of mechanical failure and classable as unpreventable accidents. The remaining 82.8% were directly attributable to some failure in the human element, accidents which may possibly have been averted. Other investigators have been inclined to place the man failure percentage of accidents at an even higher level. In the light of all available data it is reasonable to assume that between 80 and 90% of all accidents are directly or indirectly attributable to man failure in some of its forms. At least one out of every five accidents has been "caused."

While the provocative causes of man failure are numerous, one, FATIGUE, stands out preeminently.

In an article in *Literary Digest* (of September 5, 1931) entitled "The Psychology of Accidents" the statement is made that "among 1,300 accidents about 25% were due to fatigue."

Another strong argument in favor of fatigue as being the outstanding contributor to accident causation is to be found in the several reports of many investigators who have studied the time of occurrence of accidents with regard to the working day. The consensus of their opinions is that, beginning in the morning, accidents gradually increase in number until a maximum is reached just prior to the noon hour, diminish sharply during the luncheon period, and then rise gradually to a second maximum, generally larger than the first, just before the close of the day's work. The writer conducted some investigations with reference to night workers and found the ratio to be in about the same proportion but with the order reversed owing to the fact that for them the work day begins in the evening and is completed in the early morning.

Before any intelligent survey of the relationship between fatigue and accidents may be undertaken, it is necessary that an answer be found to the question "What is Fatigue?"

FATIGUE has been described as being a physiological condition of the cells or organs of the body which have undergone excessive activity with a resulting loss of power. More correctly speaking, however, fatigue should be considered from both the psychical and the physical aspect.

Psychically, one who has been active for a considerable time, either mentally, or physically, or both, develops a condition familiarly described as "a tired feeling"; this sensation being one of weariness is truly a psychical phenomenon conveying no comprehension of any physical changes in the body tissues although important material changes have, in fact, taken place. Physiologists have been giving much concern in their endeavor to determine in just what these changes really consist, and even yet some are not fully understood.

Physically, the phenomena of fatigue within the living body are exceedingly complex; all organs and tissues must of necessity work to a greater or less degree in unison, and excessive work upon the part of one body structure will increase the functional activity of others. Thus the action of the central nervous system is demanded in order that any muscle or group of muscles may be brought into play, the said muscular action in turn demanding increased work on the part of the heart and respiratory organs, so that the augmented demand for oxygen may be adequately met. At the same time there occurs a stimulation of the various glands to increased activity, inducing more secretion and demanding an acceleration of function on the part of the eliminatory system.

The internal or inherent power which undergoes a loss following excessive bodily, mental, or nervous activity is described as "energy." Decrease in this energy is attributable to changes having taken place in those yet unknown energy-holding compounds of the body as well as to a reduction in the available number of such compounds. This really constitutes the first etiological factor in the production of fatigue. The other prime factor in fatigue production is found to arise from the accumulation of poisonous waste materials within the body, these being the so-called "fatigue substances." Time will not permit of a detailed consideration of the chemistry concerned in fatigue; within the scope of this article we may only briefly outline the changes which occur when muscular tissue is brought into action. Glycogen is the chief source of muscular energy. When muscular contraction takes place the available oxygen enters

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* Read before the Twenty-Sixth National Safety Congress and Exposition of the National Safety Council, Kansas City, Missouri, October 11-15, 1937, and abstracted in *National Safety News*, November, 1937.

into a chemical combination resulting in the disintegration or combustion of its glycogen, followed by the formation of carbon dioxide and lactic acid, both of which are powerful underlying contributors toward the induction of muscular fatigue and constitute the etiological factors, while the exciting factor is work.

Resultant upon fatigue, the individual's ability to perform is lowered, his output decreased, the quality of his production diminished, his mental aptitude lowered, his susceptibility to disease increased in a direct ratio to the lowering of his vitality, his liability to commit errors is heightened, and, last but by no means least, his liability to sustain personal injury is greatly enhanced.

In all body activity a certain degree of fatigue is developed which is harmless so long as complete recuperation occurs, i.e., so long as oxygen and glycogen are supplied in adequate quantities to compensate for the combustion that is taking place in the activated musculature, and the "fatigue substances" are promptly and completely eliminated. When these requirements are not fully met the condition known as fatigue reaches a pathological status.

While carbon dioxide and lactic acid have been mentioned as being the "fatigue substances" developed in muscle tissue as the result of work, there are, under similar conditions, formed and accumulated in the brain and nerve tissues somewhat analogous katabolic substances productive of mental and nervous fatigue. Mental fatigue follows exertion which requires deep and prolonged thought, particularly along some single line. Nervous fatigue is induced by the expenditure of nerve force and follows the prolonged enforcement of body exertion beyond that point where physical or mental fatigue has become manifest. The exhausted brain worker, or one with an overly expended nerve force, is in no condition to continue the performance of physical labor, and his accident hazard is greatly increased.

IN ORDER to understand the relation of fatigue to accident prevention, attention must be directed toward the individual conditions known as being inducive of fatigue. Only in this way may the occurrence of accidents be averted. Paramount among such factors are to be noted the following:

ENVIRONMENTS: The workers' environments play so important a role in the causation of fatigue that his home surroundings and general living conditions become of as great importance as are those connected with his work. A workman whose home is unsanitary and unattractive, whose family relationships are causative of anxiety, whose conjugal mate may have become a drug addict, or who is continually harassed by the worry naturally attendant upon some severe or chronic illness in his family, becomes an active candidate for very early development and manifestation of fatigue. Such a person is a hazard to himself as well as to others with whom his occupation brings him into close working relationship. Although social welfare organizations have accomplished much toward the correction of these evils, there still remains a vast field for further study and improvement.

The physical status and mental bearing of his fellow workers reflects upon the individual to such an extent that it may become productive of fatigue and is, therefore, to be considered from the environmental standpoint.

The inadequate or improper delivery of heat, light, and ventilation in plants and offices adds greatly to the rapidity with which fatigue becomes manifest. Such conditions are always remediable and may be readily detected during the progress of an engineering survey. Their correction will constitute a step forward in the cause of safety.

GENERAL HEALTH: Those whose physical standard is impaired by poor health, with the consequential lowering of vitality, will exhibit fatigue in a much shorter period of time and with very much less physical and mental exertion than do normal beings. They are, therefore, more prone to sustain accidental injuries. Attention to the physical status of employees will accomplish much toward economical improvement as well as accident prevention. At this time it would be impracticable to deal with all the ailments to which flesh is heir that might be recognized as being productive of fatigue; only passing mention can be made of those which seem most important.

Tuberculosis, while affecting all classes, is unquestionably more prevalent among those engaged on the labor side of industry. Not only are tubercular subjects prone to present a lowered vitality which renders them more subject to fatigue and accidents, but also the transmissibility of the disease makes of them potential hazards for their fellow-workers. For many years the Anti-Tuberculosis Association has rendered a magnificent service in caring for these unfortunate individuals. Their efforts can be greatly augmented by the regular periodic re-examination of employees. which will greatly aid in the early detection of incipient infections at a time when they are most amenable to arrest.

Diabetes, another systemic disease accompanied by early fatigue manifestations, may also be readily detected during a physical examination, and can be controlled by a properly prescribed diet augmented by the administration of insulin at the hands of competent physicians. Not only is the accident hazard, through fatigue, greater in diabetics, but wounds sustained by these persons are slower in healing and convalescence may be very greatly prolonged. Since either the excess or improper administration of insulin may be followed by serious manifestations, all persons requiring this form of treatment should remain under the regular surveillance of competent physicians.

Cardiovascular-renal conditions include all of the generally so-called heart diseases, kidney diseases, and circulatory disturbances — including blood pressure. Any one of these conditions will sooner or later be followed by an associated condition in the other organs; these are usually considered as a single syndrome for general purposes.

The ease and rapidity with which these subjects become fatigued renders them of interest in this survey.

SYPHILIS stands out as the greatest industrial hazard from the standpoint of disease. It is in the first and third stages of syphilis that its industrial relation is of most importance. During the first stage a sense of shame, a certain amount of fear and anxiety, and a realization of the seriousness of the malady react upon the individual's mental faculty to such an extent that fatigue is more rapidly induced. Throughout the second stage the disease is usually sufficiently quiescent to produce little or no disturbance in the subject's mental equilibrium. The third stage is most hazardous from the industrial standpoint, since it is at this period that the brain and spinal cord become involved and neural manifestations appear. No longer is it a question of fear or shame that reacts upon the individual; there is an actually diseased mentality. The subject becomes inefficient, manifests fatigue under extremely slight provocations, and becomes exceedingly liable to sustain accidental injuries from which recovery is generally greatly retarded. Until recently syphilis has been under such a moral and social taboo that every effort has been exerted to keep its presence hidden, and much irreparable damage has resulted. It is now becoming recognized as a physical ailment which requires intelligent handling and scientific treatment from its very incipiency. Detected in its early stages, syphilis is curable and the catastrophies attendant upon the tertiary stage may be averted.

Adaptation to Work: By force of necessity, and cognizant of the condemnation "In the sweat of thy face shalt thou eat thy bread," many individuals seek any available form of employment without having regard for their own adaptation to the work. Any person unfitted for the labors he is required to perform will become fatigued with a remarkable degree of rapidity. Industrial heads, when considering the employment of men, should endeavor to see that each individual is suited to the class of work assigned him. Attention directed along this line will result in the lessening of fatigue, the increasing of efficiency and the decreasing of the accident hazard.

Working Hours: It is not our purpose to assume a partisan attitude toward the adoption or non-adoption of any fixed schedule of hours for labor. Those who have had actual and practical experience know that in some instances shortening of the day's work has really resulted in an increase in the amount of work done. One occupation will be found far more fatiguing than another. Our present interest is centered upon over-fatigue, which is recognized as being causative of accidents.

There are in general use many labor-saving devices, the operation of which produce much noise and vibration and require high speed attention on the part of the operators. Such inventions unquestionably save much labor and yet have a tendency to greatly increase fatigue.

Monotony, another cause of emotional fatigue, deserves consideration under this heading. Rest periods have been found to prevent and relieve fatigue when interspersed with the day's work. These rest periods may often be of no more than five or 10 minutes' duration and their frequency governed by the monotonous nature of the employment. Actual experience of industries where such rest periods have been instituted bears out their practicability in that fatigue has been lessened, production increased, and accidents minimized.

Noise: Though scientific experiment has not as yet definitely demonstrated the fact that working under conditions which expose to continuous noise is productive of fatigue, it is generally accepted as an axiomatic fact. Exceedingly loud noises, those of a droning nature, and rapidly repeated and monotonous noises are particularly prone to induce fatigue. It would appear that the character and quality of noise are of the greatest importance and, where they cannot be eliminated, efforts at changing or supplanting the character of sound have met with remarkable success. By means of loud speakers installed throughout many factories in Germany the rhythm of music has been used to overcome the hum of machinery. The practice is just beginning to permeate in American industry; in English and South American factories it has been in vogue for some time past. The President of the American Federation of Labor is accredited with having said "Music is a friend of labor; it lightens the task by refreshing nerves and spirit." The idea of music during working hours is not new; it was in vogue in ancient Greece where special work songs were used during the performance of certain labors.

Posture: Incorrect posture is a most important factor in the causation of fatigue and its attendant accidental hazards. Man having assumed the upright position, all studies of posture must consider this as being his normal attitude. A perpendicular line drawn alongside the standing figure should pass through the center of the ear, center of the shoulder, center of the hip, center of the outside of the knee, and center of the external malleolus at the ankle. Such a posture requires the minimum of physical exertion for its maintenance since the parts of the body are so superimposed upon each other that the force of gravity replaces much muscular effort. The correct seated posture maintains the above relation with the head, torso and hips; the thighs are at an angle of approximately 90° with the body, while the knees are flexed so that the feet rest firmly and comfortably upon the floor. When work requires that the body be inclined forward so as to accommodate itself to a desk or machine, this position should be assumed by a pivoting at the hip joints and not by permitting a slouch in the spinal column.

The general ill effects of an improper sitting posture result from the disturbances in function of the organs of the body resultant upon a flattened chest, rounded shoulders, obliteration of the natural curvatures of the spine, protrusion of the abdomen, removal of the natural support provided for the heavy abdominal viscera by a natural

shelving of the spine where these organs rest and are retained by the abdominal muscles, undue stress upon supporting ligaments, retardation of circulation, undue pressure upon that sensitive area surrounding the lower end of the spine and the coccyx, and undue pressure upon the nerves, arteries and veins passing through the popliteal space at the back of the knee joint. When, due to improper posture, the heart's action is impeded there is noted a diminution in both the quantity and quality of the blood's supply with a corresponding depreciation in available oxygen and glycogen, accompanied by a retention of the "fatigue substances." The invariable result is a rapid manifestation of fatigue symptoms. The subject begins to feel sleepy, yawns frequently, responds but sluggishly to external stimuli, lags in the performance of work, becomes inefficient, and is far more liable to accidental injuries.

Many workers have been provided with no seat whatever, others with improper seats or chairs which do not admit of adjustment either to the individual's anatomy or to the work entailed. Due to the exceedingly inefficient character of such seats, piece-workers can rarely be induced to use chairs of ordinary construction while at their labor. What one industrial engineer said with regard to the average factory chair is equally applicable to the general run of office and industrial seating. Comparing it to a coffin he said: "The man who made it didn't want it, the man who bought it didn't use it, and the man who used it didn't have anything to say about it."

For all forms of industrial seating chairs should be of sturdy, preferably metallic, construction. The seat must be adjustable in height from the floor except where the occupant works at a high desk or machine, when the adjustment should be from a stand or foot-rest. Seats should be sufficiently broad to make them comfortable but never sufficiently deep for the front edge to impinge against the popliteal space exerting pressure upon the nerves and vessels at the back of the knee. The rear edge of the seat should not extend sufficiently far back to exert pressure upon the lower end of the spine. The ideal seat is one approximately 17 inches in width and not more than 11 inches in its anteroposterior dimension. A slight saddle-shape is entirely permissible. Chair backs must be so designed as not to come into contact with the shoulder blades; to do so markedly interferes with free shoulder and arm movements. These backs should be thoroughly adjustable in both the vertical and horizontal planes and when properly fitted to the individual who is to occupy the chair, will afford support to the lumbar region of the spine—the locality where bodily fatigue is first noted. Executive, clerical and factory chairs are now available in the construction of which every anatomical, physiological and scientific factor has been given full consideration. One of the most efficient means at our command for minimizing fatigue and decreasing the accidents caused thereby is the adoption and installation of correct posture chairs, each to be thoroughly adjusted to the individual worker.

In the foregoing category have been included the more prominent, though by no means all, of the elements entering into the production of fatigue and resulting in accident causation.

MUSCLES will respond to an enormous amount of action before manifesting symptoms of fatigue. When, however, during muscular action, oxidation has been incomplete and the supply of glycogen inefficient, a rapid increase of the "fatigue substances" will occur in the muscle cells and fatigue will increase in direct proportion to the reduction of muscular efficiency. Muscles that have become fatigued will not be accurate in the directing of movements; there will be incoordination of action with other muscles—this uncertainty of movement and non-concerted action increases the accident hazards of the individual as the elements of fatigue increase.

In the presence of cerebral or nervous fatigue the mind fails to respond normally to extraneous stimuli, cerebral impulses are retarded or possibly entirely lost. Again the accidental hazard increases proportionately as does fatigue.

Should the circulatory function be impeded, whether by disease or over-exertion, the supply of oxygen necessarily becomes inefficient, full combustion of glycogen is retarded, the products of decomposition — "fatigue substances" — are inadequately eliminated, and both muscle fatigue and accidental hazard will be exhibited with far greater promptness and with increased intensity.

The workman with a fatigued mental, nervous and/or muscular system becomes a potential accident hazard; remove, or at least minimize, the sources of fatigue which surround him and his work, and much will be accomplished toward accident prevention. By far the greatest number of accidents do not happen—they are caused.

"Dr. Fishbein Speaking--"

IN RUSSIA, and in the United States if the 430 signers have their way, all matters relating to the distribution of medical care, are to be in the hands of 'experts.' And the experts in this case are naturally the social workers, the economists, and minor bureaucrats. If medicine is put in the control of the 'experts' there is no future in medicine at all. . . .

"Surely there is a fundamental threat to democracy in a system by which government takes increasing portions of income to do for its workers what they could otherwise do for themselves. . . .

"Medicine in America is on a higher plane than anywhere else in the world today. When people tell you that one third of our people lack adequate medical care, look behind the figures and see if they are not inspired by some politician who wants a change and a new job. Of course, there are the indigent. They must be cared for, as always. And we doctors who wish to preserve the best in American medicine must see to it, especially, that they are cared for. That has always been our responsibility. We do not shirk our share in it now."

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The 430 Physicians!

NEARLY everyone is familiar, by this time, with the "incident" of the 430 physicians whose endorsement of certain principles which were emphatically rejected by the American Medical Association at Atlantic City, has been given so much publicity. *Minnesota Medicine* quotes from a talk by DR. MORRIS FISHBEIN, at a Twin Cities' meeting last month, in part as follows:

"Here is the history and background of the incident. When the work of American Foundation Studies in Government approached a conclusion, Miss Esther Everett Lape, member in charge, approached officials of the American Medical Association with the information that considerable pressure was being brought to organize a group of physicians who should draw up conclusions and recommendations based upon their studies in medicine. We added some names to a suggested list. Some of the men thus invited refused to be associated with the undertaking. Later, others were invited to lunch with Miss Lape and Mrs. Roosevelt with the understanding that they would present their conclusions to the President. . . .

"The President was reported to have said (Bear in mind, one does not quote the President): What is the attitude of the American Medical profession? Does the medical profession approve?

"The little group of invitees drew up some principles and proposals that closely paralleled the resolution submitted to the House of Delegates of the American Medical Association. . . .

"Near the end of the sessions of the New York Medical Society's House of Delegates, the principles and proposals later presented at Atlantic City were passed and Doctor Kopetzky, a delegate, brought the report to Atlantic City. . . .

"The result of that fight and the definite rejection of the proposal by the House of Delegates are well known. The Principles and Proposals circulated by the Committee of Physicians, now erroneously said to have 'split' the American Medical Association, represent a new effort by the same group to carry out its plan.

"The object is to get as many good names as possible so that Congress and the public will believe in the split. The methods are questionable. The action of the men who thoughtlessly lend their names to the project is worse than questionable. It holds possibilities for serious harm. . . .

"Incidentally, I never saw a more dismayed countenance than one presented by a Chicago signer confronted by a story run subsequently in the *New York Times*. The headlines read like this: 'PHYSICIANS REVOLT IN FAVOR OF STATE MEDICINE.' Like so many others, this man was one of the inadvertent signers. . . .

"In the past three days, 60 men have written to me that they signed without any clear conception of the use to be made of their names—merely because the signers seemed to be good men, or because someone asked them, or for other trivial and irrelevant reasons."

We are deeply interested in this incident, its background, and its aftermath, because among the 430 signers there were several men who have been outstanding in industrial medicine and surgery, and whose work has contributed greatly to its forward movement. We hope, for their own sakes, that they, too, will be found among those who signed inadvertently.

Incidentally, it is reported that Senator James Hamilton Lewis (D), Illinois, who seemed so much in favor of government regulation of medicine—inasmuch as the government is regulating practically everything else, *has completely changed his mind* on the subject since he saw, first-hand, the actual workings in Europe of what he advocated in America. If the report is true, the Senator has shown one qualification of statesmanship; he is big enough to change his mind when he finds he is wrong.

The Volume Index

THE Volume Index of the 12 issues of INDUSTRIAL MEDICINE published during 1937 is not delivered with this, the last issue of the year. It is available, however, for anyone who may want it, and will be sent without charge, on request.

Occupational Diseases and Industrial Surgery

The Medical Unit Reports to Management

MUCH has been written about the growing interest of business executives in medical units and in the contribution of industrial health service to low-cost production, through improved health conditions.* This is and will continue to be looked upon as so much propaganda by many industrialists. One writer expresses this succinctly, "If it is not necessary to output, put it out," which is followed by his statement that a medical unit functioning adequately and performing great service was eliminated by an efficiency expert installed by a financial institution to assume the task or reorganization.

Professional people sometimes do not realize that business must obtain a return on its investment, whether it be an investment in man-power, machinery, or a medical unit. In modern industrial organization, the importance of return on an investment is considered paramount. At the same time there is no subject about which so little has been written in connection with medical units. Business will be wholeheartedly behind medical units in industry only when management is given a practical analysis of activities and results obtained by the medical unit, together with recommendations for a program to bring about improved health and lower absence rates in order to cut costs. The presentation of such a report should be clear, concise, non-technical, and understandable to a non-medical reader.

We have attempted to face these facts in our reports to management, and we consider them of vital importance in interpreting the value of service. After a brief description of our health service, part of our annual report will be described and reproduced.

The medical unit of the Chemical Bank & Trust Company was organized in 1934. The bank—which covers Manhattan and Brooklyn, New York—is composed of 12 branches beside the main office, and employs about 1,500 people. The unit is composed of a non-resident consulting physician and a full-time nurse. Typing service is furnished from the secretarial department.

The physician makes pre-employment examinations, and subsequent examinations in special cases when requested to do so. Employees who have no family physician and who wish to go to the consulting physician for further consultation are given special financial consideration. He is called for emergencies requiring the immediate service of a physician.

The nurse has the responsibility for day-by-day health supervision of employees. She receives a report of the pre-employment medical examinations from the physician—who makes the examinations in his office—and does the follow-up to secure correction of defects and handicaps. She gives first aid in injuries when needed, though emergencies are a very minor part of the work in a business of this type. She checks up on all absences due to illness after the employee returns to work, and ascertains the cause.

The health service is centralized and the employees come to the main office to see the nurse. After absence due to illness, all main office employees report to the nurse before returning to work. Branch office employees are not requested to report to the nurse for an absence of less than two days. This routine is frequently waived depending upon the type of case and previous health record of the employee. The nurse sends a form report to the department head or branch manager after the

* FLORA K. ARNOLD, R.N., Industrial Nurse, Medical Unit, Chemical Bank & Trust Company, New York City, in *Public Health Nursing*, November, 1937.

Occupational Diseases

The General Assembly of the State of Illinois has recently passed an Act, covering occupational diseases of Industrial employees. This Act is particularly concerned with diseases of the lungs, and poisoning from certain chemicals.

Under this new law it will be necessary for many industries to examine their present employees, and new employees, to determine their present health status and thereby prevent future liability.

We are a diagnostic laboratory, fully equipped to make x-ray examinations of the lungs, tests of the urine and blood for lead, and all examinations specified under the new law.

All members of our Professional Staff are approved by the American Medical Association.

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CHICAGO

Facilitating the control of venereal disease

THE nationwide campaign to eradicate syphilis is receiving valuable publicity from many sources, and is resulting in a greatly increased number of individuals seeking treatment.

To facilitate the control of venereal disease and in recognition of the important rôle played by the private practitioner in the campaign to control syphilis, E. R. Squibb and Sons (as of October 14th) made substantial reductions in the cost of Neoarsphenamine, Arsphenamine and Sulpharsphenamine. These new prices approximate those hitherto available to large clinics. They enable the private physician to treat his luetic patients economically with high quality Squibb Arsenicals.

Neoarsphenamine Squibb is prepared to produce maximum therapeutic benefit. It is subjected to exacting controls to assure a high margin of safety, uniform strength, ready solubility and high spirocheticidal activity. Equally effective when indicated are Arsphenamine Squibb and Sulpharsphenamine Squibb.

Iodobismitol with Saligenin provides all the systemic effects of bismuth in the treatment of syphilis. It is a propylene glycol solution containing 6% sodium iodobismuthite, 12% sodium iodide and 4% saligenin (a local anesthetic). It presents bismuth largely in anionic (electro-negative) form—is rapidly and completely absorbed and slowly excreted, thus providing a relatively prolonged bismuth effect.

For literature address Professional Service Department, 745 Fifth Avenue, New York

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Central States Society of Industrial Medicine & Surgery
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THE object of this Association shall be to foster the study and discussion of the problems peculiar to the practice of industrial medicine and surgery; to develop methods adapted to the conservation of health among workers in the industries; to promote a more general understanding of the purposes and results of the medical care of employees, and to unite into one organization members of the medical profession specializing in industrial medicine and surgery for the mutual advancement in the practice of their profession.

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ANNUAL MEETING

THE 1938 Annual Meeting of the American Association of Industrial Physicians and Surgeons, and the 1938 Midwest Conference on Occupational Diseases, will be held at the Palmer House, Chicago, June 6, 7, 8 and 9, 1938.

employee returns to work. In certain cases a certificate from the family physician is required for an employee who has been absent over four days. Employees also report to the nurse, on the advice or permission of the department heads or branch managers, for special reasons. These visits to the health office are made on bank time. The nurse visits the branches periodically or on call, for consultation on health problems or environmental conditions that cannot be handled in the main office.

Since the nurse is the full-time member of the medical unit, it is her responsibility to make the reports of the service. Monthly and annual reports are made to the personnel director, who is a member of the management committee. The report is read by the various members of the committee, all of whom are officers of the bank. The first monthly reports which were made after the unit was started in 1934 contained a careful causal analysis of absences as compared with the previous month and the same month of the previous year; a list of the factors that might be entering into an increase or decrease in absences; a notation on the responses of employees to the new regulations of the management in regard to reporting after illness and the effect of this measure in preventing loss of time from relapses; an analysis of potential absentees, with medical recommendations regarding corrections of defects; a causal analysis of absences with number of days lost classified by departments; and an analysis of cases handled according to disposition of the cases.

Now that three years have passed, it is no longer necessary to present quite such detailed monthly analyses. Significant facts are reported each month; and unusual occurrences—such as an unusual amount of absence from epidemics of colds—are studied, especially in comparison with absences in other similar business organizations, and are reported to management. A very detailed annual report is still made, and portions of the 1936-37 report are reproduced here with the permission of the management in the hope that they may add to the material on this subject and be of interest to other industrial nurses.

Annual Report—1936-1937

FOREWORD: In this, the third annual report of the medical unit, we have attempted to make comparisons which will be of assistance in formulating the program to be followed by the unit during the coming year, so that everything possible may be done to reduce, by prevention, the most frequent and costly ailments. During the three years the unit has been in existence it has been proven that many ailments can be prevented and more serious cases alleviated if they are detected in their early stages. The prevention of disease is now recognized universally as

being far more important and less costly than treatment and cure.

Considerable research work has been done by us, in the bank and through outside companies. The consensus is that the desired results for better health and for a decrease in rate of illness among employees cannot be accomplished with halfway measures. Our program now lacks an annual physical examination. This is accepted as the most valuable means of discovering incipient conditions for which corrective measures can be instituted early, before irreparable damage has been done.

Although it is realized that it is in no sense the aim of management to maintain a health service as a major objective, the health service in industry has reached its present important position through the gradual and increasing recognition and appreciation of its potential contribution to the original objective—production at low cost.

INCREASED USE OF FACILITIES: The percentage of employees using the facilities increased from 60% in 1934 to 95% this year, indicating that employees have recognized and are taking advantage of the benefits to be derived from the unit.

COMMENTS ON ABSENCES AND CAUSES: Absences (in days): Total absences; Increase of absences over 1936; Total sick leaves (enforced and by permission); Increase of sick leaves over 1936.*

Sick leaves include surgical operations to correct conditions which will tend to decrease recurring absence in this group.

Despite the epidemic of grippe and influenza during the past winter, our absence did not increase proportionately with the increase in number of people employed. Saturday and Monday absences due to illness frequently showed an increase over the balance of the week. Certain departments (enumerated in report) had higher absence rates—both number of absences and number of days absent—than other departments. The type of work and working conditions may have influenced these higher rates.

Causes: If we are to accomplish our aim of improved physical condition of our employees with the resultant reduction in absence, we must systematically attack the causes of the most frequent and longest illnesses. An analysis of absences in relation to causes shows that:

Of the total *number of days* of absence, respiratory ailments, major operations, circulatory and genito-urinary ailments caused 70.3%.

Of the total *number of absences,* respiratory, digestive, and one-day ailments (branches unchecked) represented 77.5%.

"Respiratory ailments" heads both lists and represents a real problem. The medical director of a large busi-

* The actual figures have been omitted, for the most part, from this reproduction of the report.

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ness states they have been using oral vaccine for the past two years for "cold susceptible" employees. They have been very much encouraged with the results obtained, and plan to repeat the use of it this year. The simplicity of the vaccine's administration and the fact that their medical unit has not been informed of any unfavorable reaction to its use are greatly in its favor.

The fluoroscopic examination (with x-ray study when necessary), included as of April 15, 1937, as a routine part of the pre-employment physical examination, is a step universally recognized as a most reliable means of detecting minimal tuberculous lesions. Our experience has been too short to make any comments other than that we have not employed anyone with recognized tuberculosis. Our medical consultant will submit his report at the end of six months. It may be said, however, that unless we follow this with a routine examination of old employees not fluoroscoped or x-rayed, we shall miss certain existing cases of tuberculosis, which experience has shown often exist among old employees. Sooner or later these old cases may be infecting the new employees.

Circulatory and genito-urinary ailments, diseases of the nervous system, general run-down conditions, and diabetes have been the cause of practically all very long absence among employees over 40 years of age during the past three years. These conditions could be alleviated to a great extent if they were detected *before* reaching such an advanced state. This can be done only on the basis of physical examinations.

Cost of absence: Days of absence; Average wage per day (arbitrary); Estimated cost of absence to the bank, 1936.

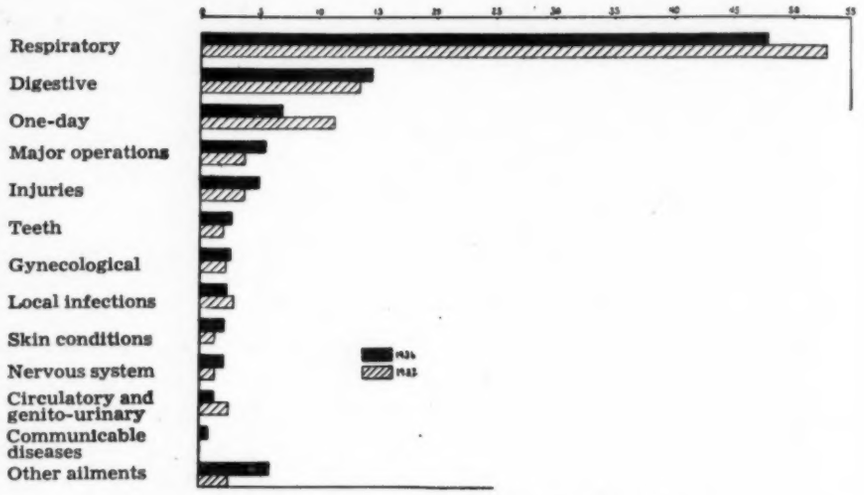
Using the Federal government statistics, that the cost is one and one-half day's salary for each day lost, the cost would be $.....

The adoption of a program of cold prevention, and control of tuberculosis and of diseases prevalent among those over 40 years of age should substantially decrease our absence. The ultimate saving should more than offset the expenditure, by improved efficiency accompanying good health. Our amount of absence did not increase proportionately with the increase in number employed, which we believe is due to the precautionary measures heretofore instituted.

COMPENSATION CASES: Number of compensation cases treated; Number of employees losing time; The longest absence, due to bursitis of the knee was ..... days.

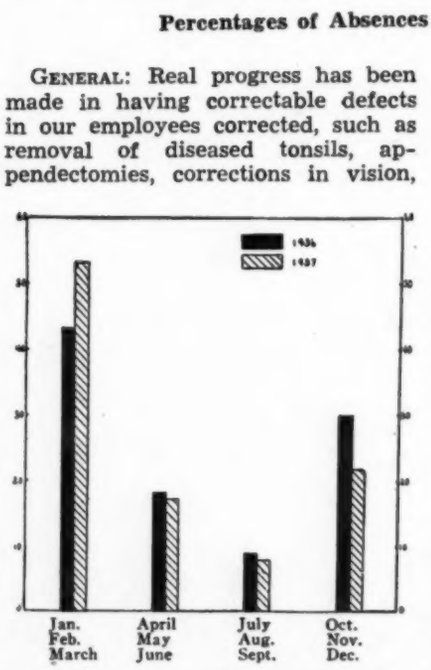
ASSOCIATED HOSPITAL SERVICE OF NEW YORK: Number of employees benefited; Total days of hospitalization; Average number of days per person hospitalized.*

CONTROL OF SYPHILIS IN INDUSTRY: There has been a great deal of study and publicity recently on the subject of syphilis, a cause of many degenerative diseases. It is felt that we, too, should participate in the distribution of educational material. We have reviewed many articles on the subject and have briefed them for perusal by management. A brochure on the subject published by the Bureau of Social Hygiene, New York City Department of Health, has been distributed to employees.*



Percentages of Absences by Cause, 1936 and 1937

GENERAL: Real progress has been made in having correctable defects in our employees corrected, such as removal of diseased tonsils, appendectomies, corrections in vision, and dental care. While this has caused some increased absence it will prevent recurring absence in the future.



Percentages of Absences Caused by Respiratory Ailments, by Season, 1936 and 1937

Many employees sought advice in connection with personal difficulties relating to family illness which have caused them a great deal of mental worry and financial concern. We have been successful in many instances in relieving such anxiety, through cooperation with the proper agencies.

POLICIES ESTABLISHED — 1936-1937:

1. Fluoroscopic examination (including x-ray study when indicated) as a routine part of pre-employment examinations.
2. Definite policies with regard to sick leaves.
3. Definite policies with regard to applicants' pre-employment physical examinations.

(These policies, established this year, are based on a study made over a period of three years.)

RECOMMENDATIONS:

1. That we establish annual physical examinations for all employees, to include as a routine the fluoroscopic examination of chest, and an electrocardiogram study on all employees over 40 years of age.
2. That we plan to make further studies on cold prevention.
3. That we more frequently use the insurance company nursing ser-

COMPARISON OF STATISTICS

	1935	1936	1937
Number of employees			
Male			
Female			
Total employees			
Employees using facilities (including officers)			
Number			
Percent of total employed			
Outside people given emergency treatment			
Cases handled			
Total			
Peak month			
Number of cases			
Month			
Days of absence due to illness (excluding officers)			
Long term (7 days and over)			
Male			
Female			
Total			
Short term (under 7 days)			
Male			
Female			
Total			
Total			
Male			
Female			
Total days absence			

* A cooperative hospital plan in New York City.

* Bureau of Social Hygiene, Department of Health of the City of New York. Facts About Syphilis. 1936. Copies of the digests of articles and of the pamphlet were attached to the report as submitted to the personnel director.

vice. This is a free service under our group policy and we feel that in many cases the length of absence can be reduced by earlier and more efficient care.

4. That branch employees having more than three one-day absences per year have a check-up to see if any chronic condition or correctable defect exists.

Tables were also included to give the following information:

1. A comparison of the service with that of six other companies, in regard to total number of employees, number of cases handled, number of days of absence, number of employees absent, average days of absence per person, and number of resident medical staff.

2. An analysis of absences according to causes.

3. An analysis of absences and days of absence for the year according to departments in which they occurred.

4. A list of the employees absent more than seven days or having more than three absences during the year, with the department, absence frequency, number of days of absence, and cause of absence.

5. A list of employees absent for an extended period of sick leave during the year, with the department, number of days absence, and cause of absence.

6. A list of employees given sick leave for surgical operations to improve their general health, on the advice of the consulting physician or the patient's own physician, with the department, number of days of absence, and operation performed.

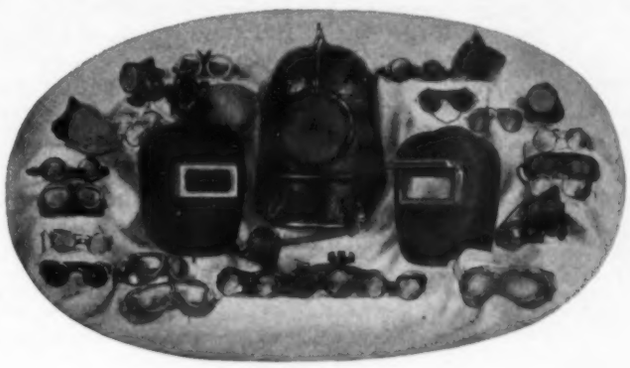
7. A list of employees showing marked deviation from average weight and in need of special attention because of glandular or other organic disturbance, with the department, and figures showing gain or loss in weight.

8. A list of compensation cases, showing the disability and number of days lost in each case; an analysis of the total number of compensation cases according to total days lost, and number of compensation cases having absences.

9. A list of the employees hospitalized under the Associated Hospital Service of New York, classified according to the name of hospital, the number of hospital days, and the diagnosis.

DISPOSITION OF CASES HANDLED

	1935	1936	1937
Surgical aid			
Medical aid and advice			
Follow-up of cases, including check on medical cards			
Referred to doctor			
Employee's expense			
Bank's expense			
Compensation cases			
Referred to clinic			
Referred to home			
Rest periods in medical unit rest room			
Cases hospitalized			
Cases given home and hospital visits by nurse			



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Items 2-7 are used as a basis for future follow-up by the nurse.

EDUCATIONAL LITERATURE: Educational literature has been given to employees on various subjects related to their health needs and problems—such as colds, influenza, pneumonia, first aid, and keeping fit through exercise.

RESEARCH FINDINGS: During the year a careful investigation and study have been made of the industrial relations policies followed in the United States in industrial, manufacturing, and financial institutions, and a treatise on the subject has been prepared from data obtained from state and national health agencies, insurance companies, and medical units of other industries. Information on the following subjects is included in this treatise so that inferences may be drawn which will be of value in the consideration of future policies:

Medical service in industry
Diseases related to industry
Cancer
Degenerative diseases
Syphilis in industry; syphilis control program
Diabetes and tuberculosis—a change in the mortality picture
Meeting the tuberculosis situation
The cost of tuberculosis to industry, to the individual, and to the community
Most frequent causative factors of heart disease
The work environment and fatigue
The physical examination
  Preemployment examination
  Reexamination
Objectives of industrial health nursing service.

The Industrial Doctor

OFFICIAL SECTION OF THE NEW YORK STATE SOCIETY OF INDUSTRIAL MEDICINE

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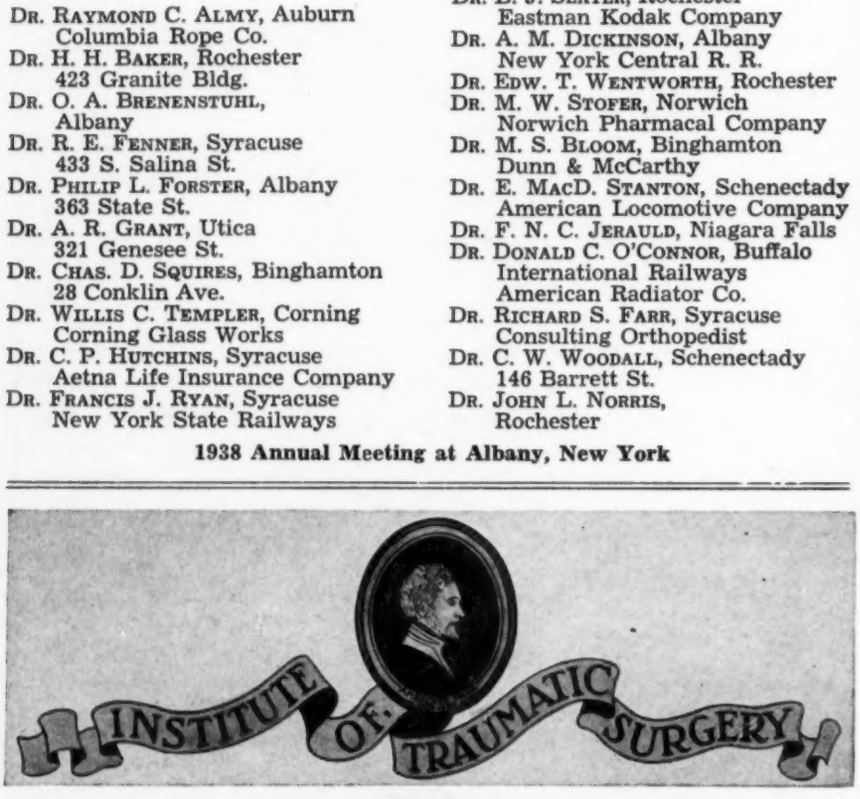

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Toxic Effects of Carbon Dioxide

SIR JAMES SIMPSON in one of his papers in 1856 said: "Carbon dioxide is usually recognized by toxicologists as a very powerful narcotic poison when inhaled in sufficient quantity."* He pointed out as a practical proof of this statement the following situation. The walls of the Grotto del Cane near Naples are said to emanate steam and carbon dioxide in sufficient quantity to form a stratum of carbon dioxide near the floor, in which dogs are either anesthetized or thrown into convulsions and finally asphyxiated, while their masters, breathing the lighter, purer air above, are unaffected.

It is my desire to call to your attention a condition which is all too rarely appreciated by present-day clinicians. For want of a better name, it may be referred to as carbon dioxide poisoning. An anesthetist's interest in the subject is perhaps logical, since many, if not most, of his difficulties with inhalation anesthesia originate from interference with the normal transport of oxygen, carbon dioxide, and the anesthetic agent to and from the cells of the central nervous system. A knowledge gained through an experience of over twenty years as an anesthetist, leads me to discuss the subject. To illustrate the fact that carbon dioxide may be a poison, the following extract from a letter written by a former undergraduate student bears witness. He writes:

"The patient was a well developed girl of fifteen who entered the hospital with a chief complaint of tenderness localized at McBurney's point. Her temperature was 101.8° F., her pulse was about 85, and respirations 20. Chest examination was negative. An appendectomy was advised. To produce anesthesia, I employed nitrous oxide induction followed by ether, with the absorption technic. The machine did not absorb carbon dioxide very well at any time. The anesthesia was well established with ether, and the operation begun, the patient having excellent color, respirations about 26, pulse 90, pupils small and extrinsic muscles of the eyeball paralyzed, when she begun to have small constant twitchings of the face. A short time later there appeared a small clonic body convulsion. I thought of anoxemia as a cause even though respirations were not depressed, pupils small, pulse good and color good. Oxygen was administered, ether was deepened, then abandoned, then reapplied and various other procedures tried in an attempt to relieve the situation. These efforts included giv-

* RALPH M. WATERS, M.D., Madison, Wisconsin, from the Department of Anesthesia, Medical School, University of Wisconsin. The investigation was supported in part by the E. R. Squibb & Sons' Research Fund. It was presented before the First New Orleans Graduate Medical Assembly, March 11, 1937, and was published in *New Orleans M. & S. J.*, October, 1937.

ing a lot of carbon dioxide because of possible alkalosis. The convulsions continued, getting steadily more violent, her pulse rose to 120, and her temperature obviously increased. A half hour after the onset of the convulsions she died. This case has been widely discussed among our hospital staff members, and no adequate explanation offered. The surgeon says it was a case of too much ether, our anesthetic technician believes it to have been anoxemia, and the pathology department, after a complete postmortem examination including the brain, concluded that it must have been asphyxia, largely because of essentially normal findings."

In answering the letter, his attention was called to former instruction in regard to the toxicity of carbon dioxide, referring to his own statement that the apparatus used "did not absorb carbon dioxide very well at any time," that the patient was exactly the type likely to be hypersensitive to carbon dioxide, and that this gas had actually been used to treat his patient after toxic manifestations had begun. The reply in part was as follows:

"Yes, I should have known better about the whole matter. I now remember how, just before the patient expired, I had given her a constant stream of oxygen by way of the direct shunt valve, hardly having her rebreathe any exhaled gases, because that seemed to be the only thing which kept her at least partially from failing."

He then adds a case report which illustrates the toxic qualities of carbon dioxide in other than anesthetic circumstances.

"Early this morning, I was called to the ward to see a premature infant that was blue and hardly breathing in spite of a steady stream of carbon dioxide 5% and oxygen 95% or carbogen. It gave occasional twitching gasps. This time I recognized carbon dioxide toxemia, so gave lots of pure oxygen at once, and the infant rapidly improved. After being given some saline subcutaneously and one-half hour of pure oxygen, it was crying lustily and in good condition. It seemed spectacular to the nurses how oxygen, not carbogen, was effective.

"In this hospital, I have been able to count fifty carbogen cylinders and only two oxygen cylinders available for therapeutic purposes."

If this man's experience was an isolated instance, it would be of little significance. On the contrary, his letter is one of many received in my office describing fatal and non-fatal cases of carbon dioxide poisoning. It is my belief that atmospheres containing excess carbon dioxide are frequently toxic and often fatal to certain individuals. If illness has interfered with normal metabolism, or if the transport of this waste product from the cells of the body to the environmental atmosphere is handicapped by biochemical abnormality, by respiratory or cardiac deficiency, or by drug effect, any increase in the tension of carbon dioxide in the atmosphere inspired may prove detrimental.

EFFECT ON NORMAL SUBJECTS: A brief and incomplete review of the literature will refresh our minds as to the effect of carbon dioxide rich atmospheres on normal animals and men. Statements of Haldane and Smith in 1892[1] have frequently been verified that ten per cent carbon dioxide in the inspired atmosphere is the upper limit which can be inhaled for any length of time without stupefaction. This fact had been demon-

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strated in animals long before 1892. It is, of course, a familiar fact that Hickman advocated surgical anesthesia with this agent during the first quarter of the nineteenth century[2]. Davies, Haldane and Kennaway in 1920[3] found that the inhalation by normal individuals of 5.2% to 6.4% carbon dioxide for two hours was followed by headache lasting for several hours after its removal.

Goldstein and Dubois[4], in 1927, studied the effect of carbon dioxide inhalation by normal individuals. They demonstrated that when the inspired air contains less carbon dioxide than alveolar air, that is, up to 5 or 6%, there is no increase in alveolar concentration. In other words, normally the increased ventilation is able to keep down the alveolar concentration so long as the atmosphere inhaled does not contain an excess over the normal alveolar carbon dioxide. As the level of alveolar tension is reached and exceeded, in the inspired air, the alveolar tension gradually increases until it approximates that of the inspired atmosphere at the end of the experiment. They found that there is a rise in systolic blood pressure with increasing concentration. The extent of the systolic rise, they found to be dependent on the ability of the subject to continue to rebreathe, reaching 60 millimeters and higher before their conscious subjects refused to continue. They also observed a rather extreme change downward and then upward in the diastolic pressure just following the period of inhalation.

In 1929, Leake and I[5] reported investigations of the effects of carbon dioxide in which mixtures of this gas with oxygen were utilized to induce anesthesia in dogs. We found, as had many others, that the extreme rise in blood pressure took place with concentrations under 30%, whereas with 30% and over, after the initial rise, the blood pressure often remained approximately normal during periods when there were no convulsions, and that respiration likewise tended to be normal or depressed. As concentrations above 40% were reached, there was definite depression of both respiration and circulation. When a gradual increase in carbon dioxide concentrations to very high levels was displayed to dogs, it was found that both respiration and circulation finally ceased approximately at the same time, rather than in the sequence usually noted with anesthetic agents; namely, a cessation of respiration long before the heart stops. The outstanding finding of their work, however, was the frequent occurrence of convulsions in their animals at some period either during or following the carbon dioxide inhalations. We then attempted to administer 30% in oxygen as an anesthetic agent to three apparently normal women, with the following result. The first was satisfactorily anesthetized for thirteen minutes with no untoward result during inhalation. The second had a convulsion on the operating table, during which the ward nurse appeared in the doorway to ask, "Doctor, what shall I do? The first patient is in a convulsion." The third patient tolerated ten minutes of carbon dioxide anesthesia, which was then changed to nitrous oxide. That evening, none of the three appeared to be the worse for the experience.

Brown in 1930[6] studied the physiologic effects of concentrations between 5.5 and 12.4% in the inspired air of normal men. He found that when his men began by the inhalation of 10.4%, the maximum period which this could be endured without severe alarm, either by the man himself or by the observer, was two and a quarter minutes. When inhaling an atmosphere of 12.4%, the maximum period was two minutes in one individual only, the others abandoning the effort much sooner. Brown was convinced that 10% was the maximum concentration which could be inhaled for longer than ten minutes by any individual without loss of consciousness. He noticed, as had many others, that the respiratory rate when inhaling excess carbon dioxide was only slightly increased, the depth greatly increased, and the pulse rate moderately increased. He made the following observations in regard to the increase of minute-volume respiration as determined by measurements of the expired air: 6%

CO_2 caused 203% increase in ventilation; 7½% CO_2 caused 225%; 8.8 CO_2 caused 228%; 10.4 CO_2 caused 279%; 12.4 CO_2 caused only 153%.

The sudden decrease in respiratory stimulation above 12% is significant. The influence of high and low oxygen tensions accompanying the carbon dioxide inhalation was carefully checked and found not to affect the results.

In both subjective and objective effects, all workers have found extreme individual variations. Alarming symptoms appeared early in one individual, while the same concentration was tolerated by other individuals. It is evident from the above and other experimental work that excess carbon dioxide inhaled by normal individuals causes hyperpnea, distinct and progressive increases in systolic blood pressure and other alarming signs and symptoms, both subjective and objective, until concentrations above 10% (higher in some animals) are reached, when unconsciousness uniformly occurs. Depression of both respiration and circulation eventually supervenes as the tension is increased. Inhalations of variable concentrations have, in our own hands, frequently been followed by convulsive manifestations.

In all the preceding experiments, the writers have referred to an extreme variability in the reactions found in different normal individuals, both animals and men. This brings up the question as to whether certain diseased states may not have a very definite influence on the sensitivity to the toxic effects. The mechanism by which this catabolic product is eliminated from the body is well recognized to be a complicated one. Within the last 10 years, the whole theory of carbon dioxide transport has been revised and is still far from solved. There is, however, evidence here and there in the literature that the effect of diseased states may result in modifying still further individual variability. I have previously referred to the dangers which may accompany rebreathing or the administration of carbon dioxide to persons who are ill.[7,8] Many references could be cited of cautions and warnings by clinicians in regard to excessive use of carbon dioxide. Lundy in 1925[9], in a paper advocating the value of this agent as an adjunct to inhalation anesthesia with ether, says, "From time to time the anesthetist should open the exhalation valve and smell the mixture in the bag. The odor of ether in the bag should never be stronger than the anesthetist himself can tolerate, and the carbon dioxide should never be discernible." In the same paper he says, "Too much carbon dioxide is worse than none and care should be exercised to prevent more than 5% being used. The absorption and dissociation curves of blood and tissues have been found by Peters[10] to vary under certain circumstances. In 1920, he studied the absorption

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curves and carbon dioxide tension in the blood of normal persons, and those suffering from cardiac dyspnea and from severe anemia. He concluded that, in cardiac dyspnea, there was an impairment of the mechanism for giving up carbon dioxide from the blood; and that in severe anemia, there was a diminished power of absorbing and dissociating carbon dioxide with retention in blood and tissues. In many diseased states, it is reasonable to suppose that further deviation from normal physiologic reactions may result from inhaling even moderately increased tensions.

Since the physiologic mechanism involving the elimination of carbon dioxide is incompletely understood at the present time, it is scarcely worth further consideration in a clinical paper. Certain clinical facts, however, may be enumerated.

HYPERSENSITIVE INDIVIDUALS: In my experience, some infants and children and occasional adults, toxic from acute infections, from dietary deficiency and from other causes, are often hypersensitive. Extremely hot weather, starvation and dehydration have at times seemed to result in greater susceptibility. The toxic manifestations cannot be correlated with a definite concentration of carbon dioxide in the inspired air. Physical signs of harm may occur soon after rebreathing has been instituted, after a half hour or longer of inhalation of carbon dioxide-rich mixtures, or in the period following exposure to such environment. The majority of patients tolerate excess carbon dioxide in their inspired atmosphere, apparently without harm. For this reason, it is all the more important that we be cognizant of the hypersusceptibility of the few if we are to prevent fatalities.

The physical signs which we have come to recognize as related to carbon dioxide disturbances are of two types. First, there is a group of signs in general simulating collapse. The patient may be pale with depressed respirations, often of a quick gasping type accompanied by a grayish pallor. Blood pressure is low, often without a correspondingly rapid pulse rate. Continuance of carbon dioxide administration under such circumstances may fail to produce hyperpnea and result in arrest of respiration. Free breathing without carbon dioxide, by artificial respiration if necessary, is indicated, together with parenteral fluids, oxygen, and external heat.*

The second more common evidence of the effect of excess carbon dioxide is shown in muscular activity. If, under conditions permitting accumulations in the body, the smaller facial muscles begin to twitch, the observer should think of carbon dioxide poisoning as well as of oxygen lack. Excess carbon dioxide in the inspired air should cause increased breathing. Lack of this effect should make one suspicious of toxicity. When facial twitching is first noted, immediate effort should be made to promote elimination. When action is prompt, no further treatment will be necessary. If the facial movements are disregarded, a more or less generalized mild convulsive manifestation may follow.* Even then, elimination of the carbon dioxide from the inspired air will, if the patient continues to breathe, rectify the physiologic disturbance in a majority of cases. Other than the elimination of dead space (rebreathing) and the omission or termination of carbon dioxide therapy, the most logical treatment is the intravenous administration of buffer salts, preferably in hypertonic solution. Barbiturates, intravenously, will stop the convulsion whatever its cause, but if it is due to excess carbon dioxide, such therapy is fundamentally unsound because of the accompanying depression of respiration. Deep ether anesthesia will not remedy the condition and often makes it worse. Any therapeutic procedure is useful that will cause interruption of the ill-chosen technic that has resulted in overdosage. In anesthesia, if contemplated treatment results in the removal of the face mask, the patient gradually expires the gas and recovers. On the wards, patients may not be so fortunate. The administration of a mixture of carbon dioxide and oxygen may be continued in a futile and fatal effort to stimulate a respiratory center already depressed with excess carbon dioxide. Unfortunately, the persistence of a pink color often deceives the physician.

I recognize that there are many causes of convulsions and collapse, unrelated to carbon dioxide. I merely wish to leave the appreciation that illness may so modify physiologic processes as to make a slight increase in the carbon dioxide tension of inspired air toxic to occasional individuals. Realizing this fact, the physician will be on his guard to prevent the injudicious application of such therapy. The one legitimate therapeutic use of carbon dioxide which has been accepted by all physiologists and clinicians is to increase respiratory exchange.* When carbon dioxide therapy, or the rebreathing of expired atmospheres, is practiced and no increased breathing occurs, take warning. Under no condition of abnormal physiology does nature so quickly restore herself as in the elimination of excess carbon dioxide. On the other hand, if therapeutic endeavor curtails elimination by maintaining a dead space for rebreathing or by adding carbon dioxide to the inspired air from a cylinder, a fatality may result.

CONCLUSIONS: 1. Normal response: When the air inspired by normal individuals contains carbon dioxide in excess of that in alveolar air for any length of time, extreme circulatory and respiratory stimulation takes place, later followed by depression of these functions, by unconsciousness and often by convulsions. Normal individuals vary over a wide range in the symptoms and signs caused by a fixed tension in the inspired air.

2. Pathologic states accompanying illness may handicap in the extreme the potential power of buffer adjustment designed to maintain a normal balance of carbon dioxide in the tissues and provide for sufficient elimination of this substance.

3. In a vast majority of cases, the only therapeutic value of the inhalation of carbon dioxide is the production of increased pulmonary ventilation. When hyperpnea does not result from carbon dioxide inhalation, the administration should be promptly terminated.

4. In addition to absence of hyperpnea, other signs of carbon dioxide toxicity are characterized by collapse in certain circumstances and in others by twitching of the small muscles of the face, followed by convulsions.

5. Treatment of carbon dioxide poisoning consists mainly in providing a free airway with pure oxygen or air (no carbon dioxide) as a respirable atmosphere. If respiration is depressed or arrested, brief artificial respiration, without dead space or rebreathing, may be necessary.

6. Buffer solutions and depressant drugs intravenously are of benefit but are seldom needed if the condition is recognized early.

Bibliography:

1. HALDANE, J. S., and SMITH, J. L.: The physiological effects of air vitiated by respiration, *J. Path. & Bacteriol.*, 1:168, 1892.

2. THOMPSON, C. J. S.: Henry Hill Hickman, *Brit. M. J.*, 843-845, 1912.

3. DAVIS, H. W., HALDANE, J. S., and KENNAWAY, E. L.: Experiments on the regulation of the blood's alkalinity., *J. Physiol.*, 54:32, 1920.

*A somewhat similar picture may appear directly following a period during which an individual has been subjected to an atmosphere too rich in carbon dioxide and must be differentiated from it. It is then probably due to the sudden withdrawal of excess carbon dioxide for which adjustment of the buffer mechanism of blood and tissues has been made. Perhaps the excess carbon dioxide has been blown off more rapidly than it is possible for the buffer mechanism to keep pace.

*When the mechanism of carbon dioxide transports and excretion is better understood, it may be found that excess is toxic solely by reason of its tendency to interfere with oxygen acceptance by the cells. Stated in another way, excess carbon dioxide may reduce the availability of oxygen for cell utilization. The differentiation of muscular twitching or convulsions due to too much carbon dioxide from similar manifestations resulting from lack of oxygen is not always easy. The absence of hyperpnea, when it should logically be present, is often an aid in differentiation. There is some evidence that excess oxygen accompanying excess carbon dioxide actually increases the probability of toxic manifestations.

*Rarely in modern medical practice does one encounter a patient depleted of carbon dioxide because he has breathed too deeply.

4. GOLDSTEIN, J. D., and DUBOIS, E. L.: The effect on the circulation in man of rebreathing different concentrations of carbon dioxide, *Am. J. Physiol.*, 81:650, 1927.

5. LEAKE, C. D., and WATERS, R. M.: Anesthetic properties of carbon dioxide, *Anesth. & Analg.*, 8:17, 1929.

6. BROWN, E. W.: Physiological effects of high concentrations of carbon dioxide, *U. S. Naval Med. Bull.*, 28:523, 1930.

7. WATERS, R. M.: Carbon dioxide: Its place in anesthesia, *Canad. M. A. J.*, 17:1510, 1927.

8. WATERS, R. M.: Toxicity of carbon dioxide, *J.A.M.A.*, 100:519, 1933.

9. LUNDY, J. S.: Carbon dioxide as an aid in general anesthesia, *J. A. M. A.*, 85:1953, 1925.

10. PETERS, J. P., BARR, D. P., and RULE, F. D.: I. The carbon dioxide absorption curve and carbon dioxide tension of the blood of normal resting individuals; II. The carbon dioxide absorption curve and carbon dioxide tension of the blood in cardiac hyspnea; III. The carbon dioxide absorption curve and carbon dioxide tension of the blood in severe anemia, *J. Biol. Chem.*, 45:537, 1921.

Industrial Surgery: Responsibility of Organized Medicine and of Industrial Surgeons

THE purpose of this paper is twofold: first, to point out that medical care of the industrially injured should be a direct responsibility of organized medicine, and that the medical profession through committees in State and County societies, should so direct and supervise industrial practice under workmen's compensation that each injured employee may receive the best type of medical care available under given circumstances, and at a cost consistent with the gravity of the injury and the services required; and, second, to indicate and illustrate a few of the special responsibilities of the individual surgeons doing industrial practice.*

In leading up to these subjects a brief comparison of employers' liability and workmen's compensation laws as affecting medical practice, and a brief resume of the development of industrial surgery in Arizona seems appropriate.

In the old days of employers' liability, the position of the so-called industrial surgeon was not an enviable one, and quite often, not an ethical one. No provisions were made in the law for the cost of medical care. In the case of large corporations, such as mines, factories, railroads, etc., hospital fees were collected from employees, and adequate medical and hospital services provided, either under contract, salary, or other arrangements. In all other cases, however, medical costs had to be obtained from or through the injured employee, who, as a rule, would be unable to pay suitable fees, unless they were made a part of the settlement for damages, either in or out of court. The surgeon, therefore, in many instances, in order to collect his fee, must either sue for settlement on his own account, or appear in court in the role of a biased medical witness, and be prepared, in the interest of his patient and himself, to contradict expert medical testimony given in the interest of the employer or carrier. With this legal set-up, neither the practice of industrial surgery nor that of "expert witnessing" held high repute with the medical profession as a whole, and most reputable surgeons shunned these cases from all angles. As a matter of fact, the litigation of industrially injured cases, while not being entirely responsible, no doubt has had much to do with the difficulties experienced by the medical profession in convincing the public of its high moral and ethical standards. As stated by Judge Lockwood, of the Supreme Court of Arizona:

"The testimony of expert witnesses, selected and paid for by the litigants, is so notoriously unreliable that it has even passed into a proverb, and the positive, comparative, and superlative degrees of prevaricators are frequently illustrated by 'the liar, the . . . liar, and the expert witness'."

With the advent of workmen's compensation, however, and its recognition of and provision for medical care in industrial injuries, as a responsibility of industry as a whole, the situation has entirely changed, so that during the past two or more decades, employers, employees, industrial commissions and insurance carriers, as well as the public in general, have become acutely aware of the medical feature of workmen's compensation, and have learned that timely and adequate medical care of the industrially injured pays big dividends to all, by minimizing disability and lowering compensation costs. The medical profession, too, has recognized this changed relationship between doctor and industrial patient to the end that men of the highest ethical standards and professional attainments are constantly entering this field of medicine, and industrial surgery has become a definite field of medical practice.

The provisions of workmen's compensation make its benefits available to the smallest and most isolated of employers and employees in all activities of life, so that the medical care of industrial cases becomes a responsibility of the medical profession as a whole, and the general practitioner in rural districts, as well as the trained industrial specialist in larger centers, must play his part in the progress of industrial surgery. Because of these conditions, more wide-spread knowledge of industrial practice is essential, and recognition of this need is evidenced in the fact that many schools and clinics are offering post-graduate courses covering all phases of industrial surgery.

Arizona was well prepared for the advent of ethical industrial surgery under workmen's compensation, for because of the early isolation of its mines, the companies had found it advantageous to provide their own hospital and medical care, so that when the change came, the state was already provided with numerous groups of trained industrial surgeons of the highest professional attainments, and these have formed nuclei around which industrial practice in the state has developed. Consequently, Arizona, although a state of great distances, small population, and relatively few major industries has, nevertheless, kept well abreast of the times in the development and administration of workmen's compensation laws, as well as in the medical care of injured employees.

RESPONSIBILITIES OF ORGANIZED MEDICINE: The essential difference between private and industrial practice is that in private practice the contractual relationship is between the patient and doctor; in industrial practice, a third party, the industrial commission, assumes financial responsibility, to the patient for compensation, and to the doctor for medical costs. An element in industrial practice has thus been added, wherein there is a temptation on the part of the patient to so magnify his injury as to increase compensation, and the possibility of an unwary and perhaps not too conscientious doctor helping him by letting a good thing ride along, especially if his own recompense becomes larger thereby.

The intent and purpose of the law is that the interests of both the employer and the employee are the same, namely, the quickest possible recovery of the injured employee with the least possible remaining disability, and at a reasonable cost to industry. However, because of misunderstandings of the true purpose of workmen's compensation, and because of various personal and financial interests which enter into many of these industrial cases, the main object is often lost sight of and disagreements occur at times leading to expensive investigations and hearings, and even to appeals to the supreme court. The industrial commission as the administrative and judiciary body in determining just compensation and medical costs in a given case, is well nigh helpless in the hands of an unscrupulous employee and a doctor, who, to say the least, is easy-going.

To harmonize these varying elements, so that workmen's compensation may be administered fairly and efficiently, and the practice of industrial surgery maintained on a high professional and ethical plane, is a duty and responsibility which organ-

* P. F. PALMER, M.D., Medical Advisor, Industrial Commission of Arizona, Phoenix, Arizona; Presented to the 46th Annual Session of the Arizona State Medical Association, April 1-3, 1937, Yuma, Arizona; Published in *Southwestern Med.*, August, 1937.

ized medicine owes to the state, to the employers, to the employees who become industrially injured, and above all to its own moral and ethical standards. Just as in the old days of employers' liability there was opportunity for lawyers of questionable ethics to make a racket of industrial accidents, so now, under workmen's compensation, there is opportunity for connivance of the doctor with the malingerer, and temptation for certain of our profession to over-treat patients and pad bills. The racket is still present, but the emoluments have been shifted from the legal to the medical profession. It is only through organized medicine's supervising and directing industrial practice, that our highest aims in industrial surgery may be accomplished . . .

In addition to treatment of industrial cases, the medical profession has a further responsibility to the state and its industrial commission, and that is in determining the degree of recovery in a given case, and the percentage of permanent disability resulting from accidental injury sustained during employment. In many cases the attending surgeons give insufficient information for the commission to make awards. More often, these cases are referred to the medical adviser for final opinion on disability. In case of differences of opinion, or where various complications occur, they are referred to what is known as the Medical Rating Board. This board was formed on resolution of the industrial commission, following the organization of its Industrial Relations Committee. . . .

Responsibilities of the Individual Industrial Surgeon: As the industrial commission then is dependent on the medical profession for its special knowledge and in carrying out the provisions of workmen's compensation, so is organized medicine dependent on the individual industrial surgeon if it is to maintain these medical relations with the commission and adequately discharge its duties and responsibilities to the state. It is therefore essential that each surgeon in accepting industrial cases assumes individual responsibility, not only to his patient and the industrial commission, but to the medical profession as a whole, and he must ever bear in mind the requirements of the third party represented by the industrial commission.

When an industrial accident occurs and is reported to the commission, the case is set up in the files and an immediate investigation concerning responsibility and costs is started. Depending on reports furnished by employer, patient, and doctor, the case is classified either as "accepted for industrial responsibility" or "rejected", or as is frequently the case "judgment deferred pending additional information". If accepted by the commission the case is further classified as to probable results in temporary and total disability, compensation, and medical costs. Funds are then set aside and allocated to meet the anticipated expense of the particular case.

The doctor's initial report giving a word picture of the accident and the mechanism of the force applied in producing the injury, the immediate physical effects, the probable extent of disability and treatment required, is the all important information needed by the commission in arriving at its first estimation of the case. The doctor's progress and final reports are the all important factors necessary for the commission in reaching final conclusions.

The fact that any alleged industrial accident, however trivial, may be a case for litigation later on, places an additional responsibility on the surgeon and greatly magnifies the importance of early careful examination, accurate diagnosis, and full initial report. Many of these patients do not give a full and comprehensive history of previous accidents and diseases nor of the exact details of the present accident and subjective symptoms so that it becomes incumbent on the industrial surgeon to so correlate the mechanism of the force applied at time of accident with the subjective symptoms and objective findings present at examination, that a reasonable picture of cause and effect may be had.

Moorhead has stated:

"Cases which have a medical legal bearing are very prone to breed more or less conscious exaggeration and malingering, and the experienced physician will soon find that claimants can be sorted into four groups presenting.

1. Actual injury with demonstrable symptoms—the reality,
2. Actual injury with exaggerated symptoms—the exaggerator,
3. Little or no injury with objective and subjective symptoms ascribable to other causes—the malingerer,
4. Little or no injury with feigned objective and subjective symptoms—the fakir."

In other words: Group 1 consists of wholly genuine cases; Group 2 consists of partly genuine cases, Group 3 consists of partly fraudulent cases, and Group 4 consists of wholly fraudulent cases.

A clear estimation by the surgeon of the various factors involved in an industrial case, and an accurate diagnosis, are therefore of prime importance to the commission in reaching just conclusions in industrial injuries.

Illustrative Cases: In the thousands of cases which have come up for review during the past four years many interesting and difficult diagnostic problems have been encountered.

Case 1 is represented for the purpose of calling attention to, the necessity of medical supervision in industrial practice and, the responsibility which organized medicine must assume if industrial surgery is to be developed and maintained under high ethical and professional standards.

The initial surgeon's report details the following:

Date of accident—2-24-36 (typographical error. Should be 3-29-36.)

Date disability began—4-10-36.

How it occurred—Working in stope when hanging wall fell, knocking head and left shoulder against timbers.

Nature and extent of injury—Stiffness and soreness in neck.

Will injury result in permanent defect? No.

Is above accident the only cause of patient's condition? Yes.

Has patient any physical impairment due to previous accident or disease? No.

Date of first treatment—4-10-36.

X-ray diagnosis — Crushing fracture 6 and 7 cervical vertebra.

Fortunately the doctor telephoned for authority to purchase a jury-mast for the patient. Inasmuch as the man had been walking around with a broken neck for 10 to 12 days, it did not seem that a trip to Phoenix would do him further injury, so he was called in for examination by the medical adviser.

History of Case as Given by Patient: For the past two or three years he suffered with almost constant arthritis affecting his neck and back and the joints of his arms and legs. On April 1, he developed a severe cold, but continued working two shifts—until the night of April 2, when his aching became severe and he stopped working. His throat was sore and he was coughing and ached all over. On April 8 he consulted the doctor on account of his cold. He states that the doctor asked him about any possible accident: he related that on March 29, while working in a drift, he was struck by a chunk of volcanic mud which slipped from the roof 12 to 18 inches above his head—falling on his head. He staggered over, and another chunk struck him on the left shoulder, knocking him away from more falling mud. He suffered no disturbance at the time and hence had not reported the accident, and did not feel that the accident had anything to do with the condition with which he was suffering.

Physical Examination: Man of 60, with heavily coated tongue, congested mucous membrane of the nose and throat, frequent dry cough, and complaining of general weakness, aching, and soreness. He holds his head erect, without spasm of neck muscles. The head rotates freely on the shoulders in every direction.

"X-ray Examination: Films submitted are not sufficiently clear for diagnostic purposes. They do not, however, show the crushing injury to the vertebra reported over the telephone, but do show marked productive arthritis throughout this region." Additional x-rays were ordered for the record, and the patient was advised that he might return to his home.

The following letter was received by the medical adviser, dated May 11:

"I am in receipt of a letter from the Industrial Commission containing your report on this case. Situations such as this are very embarrassing to me. When I saw the x-ray of his neck I asked him specifically if he had ever had any rheumatism in his neck. He stated definitely to me, or at least as I recall it, that he had never had any trouble before the accident.

"As you very well know, the lack of a cooling system in our developing tanks, makes it almost impossible to get a good x-ray picture. So it was natural for me to assume, in spite of the fact that the man was ambulatory, that there was some definite injury to the cervical vertebra."

The following reply was dictated:

"In reply to your communication of May 11 regarding the case of Mr. Blank, I will state that it gave me a great deal of professional pain to have to turn in a report such as I did. However, I feel this way about the matter. There are some 15 or 20 men in the state who are persistently making or attempting to make industrial cases whenever a possible opportunity presents itself, and on advice of the Industrial Relations Committee, I am making a cross index of all these dubious reports as they come in. The idea is that they will be presented through the Committee probably at the State Medical Association meeting next year.

"We feel that the medical profession owes a definite responsibility to the employers of the state as well as to the patients and ourselves, in so supervising and directing industrial practice that all ideas of falsification will be taken out of the members who are now practicing with rather lax consciences.

"Trusting that you will line up with the higher types of ethical practitioners of the state in bringing about this desirable situation, I remain, etc."

The doctor in this case is today one of the most cooperative industrial surgeons in the state. The case is reported as an example of a number of others in the files which are cross indexed under "dubious doctors' reports" and from them each member of the association may form his own opinion as to whether or not organized medicine should hold itself responsible and assume control and supervision of industrial practice.

CASE 2 is another of the same class and is presented to illustrate unnecessary costs to industry because of failure of a surgeon to correlate the circumstances surrounding accident, symptoms and x-ray findings.

This man straightened up under a wooden tank and bumped the back of his neck. More than 24 hours later he consulted the doctor for what he thought was indigestion and was much surprised to learn, after x-ray examination, that he had fractured the spinous process of the 4th and the transverse processes of the 3rd and 4th cervical vertebrae, and that his pain in the epigastrium was due to cord injury. He was put to bed in a hospital with neck extension and medical reports predict three to four months of total disability.

Progress reports state that 24 hours after instituting the neck stretching, the pain in upper extremities and trunk disappeared.

Twelve days following injury the commission received the following letter from the doctor: "This man is a very poor patient. He will not lie quietly and I feel that the best thing is to put on an adjustable brace." This was ordered by the claims department at a cost of $60.00. On October 6, a month following injury, the man and the films were brought in for examination, and the following report submitted: "After a full discussion of the accident and subsequent clinical course with the patient, and after making complete physical and x-ray examination, I am of the opinion that this man suffered an acute indigestion as the cause of his original symptoms; that there was no injury to the cervical region other than a slight contusion from which he has now recovered." The jury-mast was removed and after a day or two of neck exercise there were no further symptoms. The cost of this case of imagination on the doctor's part was $400.12, including $50.00 of the surgeon's $75.00 bill for services rendered.

Some of you may think that the claims department is unduly suspicious of medical reports, but it must be realized that not only the claims department, but the public in general, judge the whole medical profession by their knowledge of the few. The responsibilities of the individual surgeon to the medical profession is emphasized by this case.

CASE 3 is that of a man over 60 who had fallen and bruised his hip. The doctor who saw him made a correct diagnosis of minor contusion, and after a short treatment, without taking x-rays, discharged the case. Some three months later a fellow surgeon in the same town saw the old fellow on the street, limping a little, and learned of the fall and bruise, and that no x-ray had been taken. He therefore induced him to go to a third doctor, who had an x-ray machine, and get a picture. This doctor reported a healed fracture of the neck of the femur with shortening. The attending surgeon thereupon put the patient in the hospital and applied a body and leg cast. He also wrote at length to the secretary of the state medical society, advising of the carelessness of the original surgeon, and stating that he was doing everything in his power to protect the original surgeon from a malpractice suit. Fortunately for every one concerned, the film was properly interpreted at an early date and the cast removed, or the malpractice suit might have boomeranged.

Friendly cooperation among physicians and surgeons, ever holding the welfare of the patient above our own personal ambitions, would raise public estimation of the ethics of the medical profession immeasurably.

CASE 4 is a class 4 case—the definite faker—and illustrates how even the supposedly best of us can be caught off guard if we do not coordinate all things pertaining to industrial injuries, and especially x-ray and clinical findings.

This man came to Arizona from Texas, and after working a few weeks, reported that he had a fall injuring his right wrist and hand. The original surgeon reported severe contusion and strain of right wrist and hand with an x-ray diagnosis of fracture of right radius at the joint, line of fracture extending into carpal scaphoid. Ten days later the patient reported at the commission asking transfer to a Phoenix doctor. Further x-rays were taken in Phoenix and reported to show fracture of scaphoid and several other details, suggesting "they do not look like recent injuries", but adding that "the fracture of the scaphoid is most probably due to rather recent injury." The new surgeon made the following report on the case: "This patient complains of more than the usual amount of pain. He was examined carefully, x-rayed, and a new splint made, and it is difficult to determine just why he should have the pain he complains of. He will not move the wrist, fingers or thumb, but there is no evidence of nerve injury. This case will be carefully watched for arthritis or some indefinite cartilage injury, which may be responsible for his condition." Ten days later an additional x-ray study was made and reported by the roentgenologist in detail as to extensive old involvement in this wrist. In spite of this report the surgeon adds, under remarks, that "This is a serious injury and the temporary disability will be long, and the permanent disability great."

A day or so later the injured workman presented a telegram to the commission purporting to come from his brother in Big Springs, Texas, stating: "Mamma not expected to live, typhoid fever, come at once", and requested permission to leave the state for two weeks. The case was finally caught up with, on his return from Texas, and his compensation stopped, as benig a malingerer. He protested the award and his attorney demanded a formal hearing. Additional evidence was obtained from the Texas commission, however, to the effect that an injury to the same wrist was settled by compromise agreement for $500.00 in 1932. When confronted with this he gave the Arizona commission up as a bad job and returned to work. It was later learned indirectly that he had settled with two other commissions by compromise agreements for injuries to the same wrist.

These cases fortunately are not common, but quite a number have been detected and probably a number more have gotten by. The industrial surgeon must ever be on his guard and when subjective and objective symptoms do not agree look for the joker.

CASE 5 is a low-back injury presented especially to show the necessity of careful interpretation of x-ray films and of harmonizing the x-ray diagnosis with clinical findings. Where x-ray laboratories are available there seems to be a tendency on the part of the surgeon to accept the interpretation of the roentgenologist as "gospel truth". To limit errors the surgeon should make his own diagnosis from clinical findings, and if not in agreement with the laboratory diagnosis, further study should be made of cause and effect, until the situation becomes clear. This case was reported to have slipped and hurt his back while helping to lift the rear end of a truck, at 4:30 P.M. October 15. He walked into the doctor's office the following afternoon.

The initial report, dated October 21, states under "accurate description of nature and extent of injury, and state objective findings", the following: "Fracture of right transverse processes of second, third, fourth, and fifth lumbar vertebra. Suspicion of fracture of third lamina lumbar vertebra." No mention is made of physical condition of patient or of anything other than the x-ray diagnosis as made by the roentgenologist.

The films and initial report came through the medical adviser's office two weeks later, and the following memorandum was sent to the commission: "Accident described could hardly result in fractures found. Fractures are shown on film but are apparently old ones and not caused by present accident. Case in cast which may be OK for two to three weeks, in case of back strain in a previously injured back. Investigation of previous injury to back and present accident should be made."

The investigation report is dated December 15, two months following injury. The report is extensive, and but a few excerpts will be quoted: "The roentgenologist disagreed with the film interpretation of the medical adviser as to the age of the fractures, stating that because of their character and extent the man could not have gone about normally while they existed. A fellow workman, however, described the slip and fall, and how the injured man got up without apparent difficulty and continued working until the end of the shift". (One wonders at the fortitude of a man who could do this if the fractures were produced at that time.) The report states further that "both doctors were surprised when they looked at the x-rays because the bone damage was so much greater than they had suspected. The patient was reluctant to go to the hospital, but finally was persuaded to do so and was placed in a cast."

This patient was in for examination February 17, four months following accident. In his personal history he admitted that in 1930, during a football game, he was hit in the back by an opponent's shoulder. He thinks he had a fractured rib; at any rate he states he was back in practice after five or six days; that he has had no other accident which laid him up for any length of time, and that he had had no trouble with his back previous to the present accident. He describes the accident as slipping on a greasy floor while walking backwards, and that the axle which the men were carrying struck the anterior crest of the left ilium as he fell backward. He noticed some pain in his back at the time but got up without difficulty and continued with his work. The following morning he returned to work and continued until about 3:00 P.M. when, because his back was hurting, he went to the doctor. He was in the hospital 88 days, 78 days in a cast, after which he was provided with a Taylor brace which he now wears. The case was referred to the Medical Rating Board at its March meeting. The conclusions of the board were as follows:

"After reviewing the previous history of the patient, the history of the injury, and after examination of the x-ray made immediately after injury and the subsequent x-rays, it is our opinion that the fracture demonstrated by the x-ray, did not occur as a result of injury October 15, 1936, but had occurred some time prior to that date. He is now suffering from a sacro-iliac disturbance on the left side. This being the opposite side to the one on which the fractures occurred. These conditions may possibly have been aggravated by the injury. The condition, so far as the injury is concerned, is stationary, and there is no more than 5% permanent general disability from the injury."

CASE 6. This case is presented mostly because of its interest from a coincidental standpoint and to show that surgeons can at times conscientiously disagree as to exact diagnosis, as the attending surgeon and the medical adviser still do in this case.

The patient, a cowboy, was riding with cattle when his horse reared and fell backwards, the cantle of the saddle impinging the left femur against the ground. The surgeon's clinical and x-ray diagnosis was a compound comminuted fracture, mesial aspect, lower third of the left femur with fragments of bone extending into the soft tissues. Portions of bone were removed, drain inserted and hot compresses applied. Ten days later, because of infection, the wound was thoroughly opened and several pieces of necrotic bone were removed. About two and a half months later the patient was sent to the hot springs, and from there came in for examination. As the case was a compound comminuted fracture of the femur but three months old, no special examination was made other than to note some stiffness in the knee, and a clinically firm union of the fracture. No x-rays having been sent in, the patient was sent to the pathological laboratory for films, and advised that he might go home and report to his surgeon.

The surgeon still insists that it was a fracture of the femur. The medical adviser insists that the thing fractured was an old myositis ossificans which happened to be present. The films speak for themselves and make an interesting exhibit in connection with films on the seventh case, which is presented for comparison. This case, however, I believe to be a calcified blood clot in the upper mesial thigh, instead of a true myositis ossificans. The films show its early development, following contusion from a saddle horn, and its progress over a period of four years.

Believe it or not, these cases are presented in a spirit of friendly cooperation and constructive criticism. While there are many more in the files where the responsibilities for prolonged disability fall directly on the shoulders of attending surgeons, there are many, many, more where careful examinations and expert care have given excellent results, for the patient and for the employer. There is much room for improvement in medical care of industrial cases, and it is hoped that this presentation will aid in convincing organized medicine of the leadership and responsibilities it must assume if workmen's compensation is to accomplish its highest purposes.

Discussion:

DR. E. C. HOULE, Nogales: Lesions of a certain type are easy to classify along certain lines and may be crudely assessed on a money basis:

1. Fractures by location potentially threatening non-union: intracapsular neck of femur, mid-humerus, lower and mid-third of tibia, etc.
2. Fractures of bodies of vertebrae.
3. Extensive burns, irrespective of degree.
4. Multiplicity of fractures, etc.

DR. RALPH F. PALMER (concluding): In this compensation work—brought about by laymen—it must be realized that there are many faults. Our law deals with accident injury in the course of employment, yet 50% of our cases are not accident but old arthritis and other such conditions. The problems are manifold and I could speak of them by the hour and not cover the points fully. As the medical referee —the go-between so far as the commission, the patient, and the doctor are concerned—I get the point of view of all. I have enjoyed it and mentally profited by it. It is a medical problem of deep significance.

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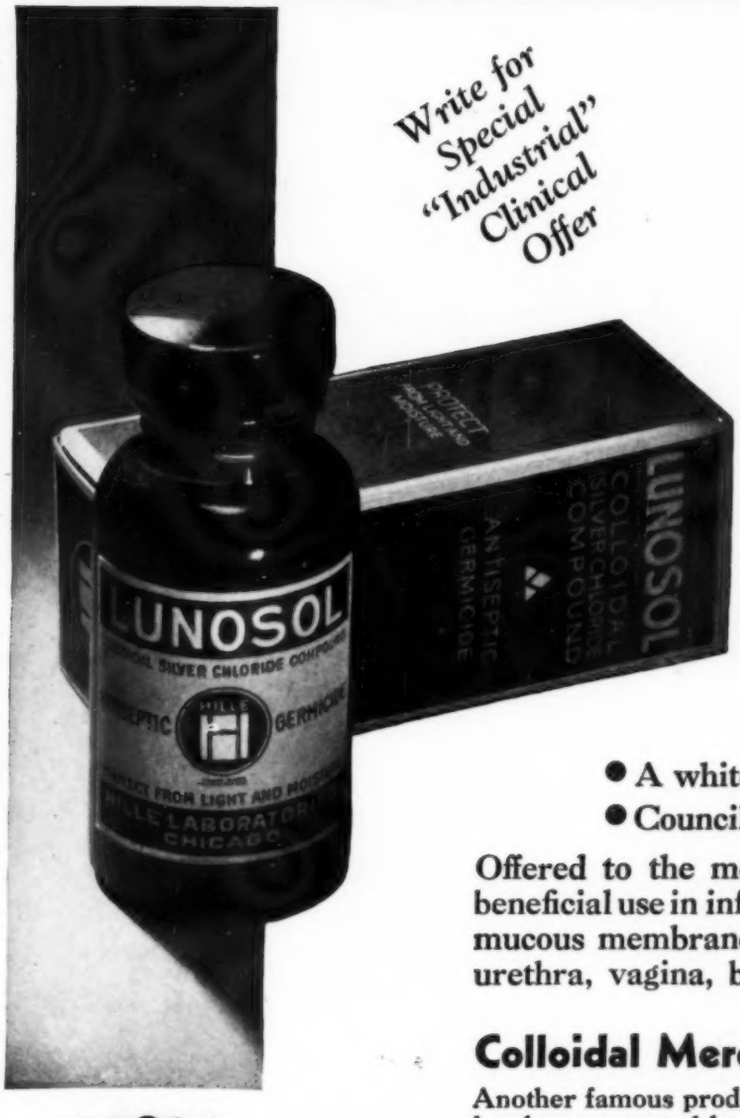

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in the Treatment of Extensive Infected Burns

Case L. S., age 16, showing burns prior to treatment with Allantoin.

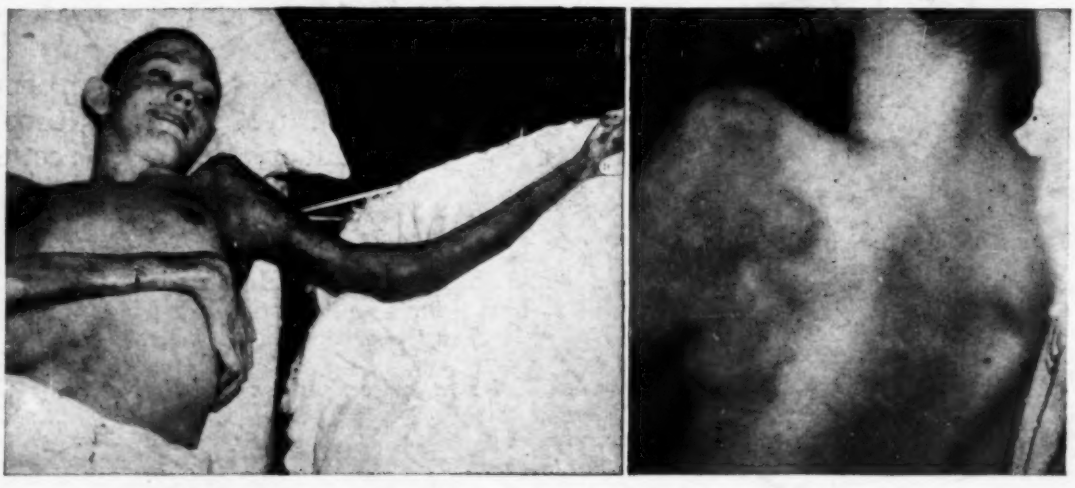
Abstract Case Report*—L. S., extensive infected burns of shoulder, arms, hands and body from explosion of gasoline torch. Non-medical treatment for two months due to economical conditions. On admission to hospital skin completely gone. Unguents and oils with moist and dry heat ineffective. Most pinch grafts implanted on shoulder, in hope of new tissue formation, so amputation below shoulder could be performed, died; remaining grafts did not spread. After several months the areas, as shown, were unhealed and covered with purulent exudate.

Treatment with Allantoin Ointment was first applied to sterile wax paper and then brought into contact with the denuded area. Epithelization began almost immediately. Young granulations advanced rapidly when treated intermittently with dry heat. Allantoin was used periodically when the tissues seemed to be lagging in their growth.

ALLANTOIN OINTMENT is of value in treating infected and slow healing wounds, varicose and other sluggishly healing ulcers.

* Case record and detailed report with Allantoin literature mailed on request.

Same case, L. S., showing new healthy tissue after treatment with Allantoin.



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